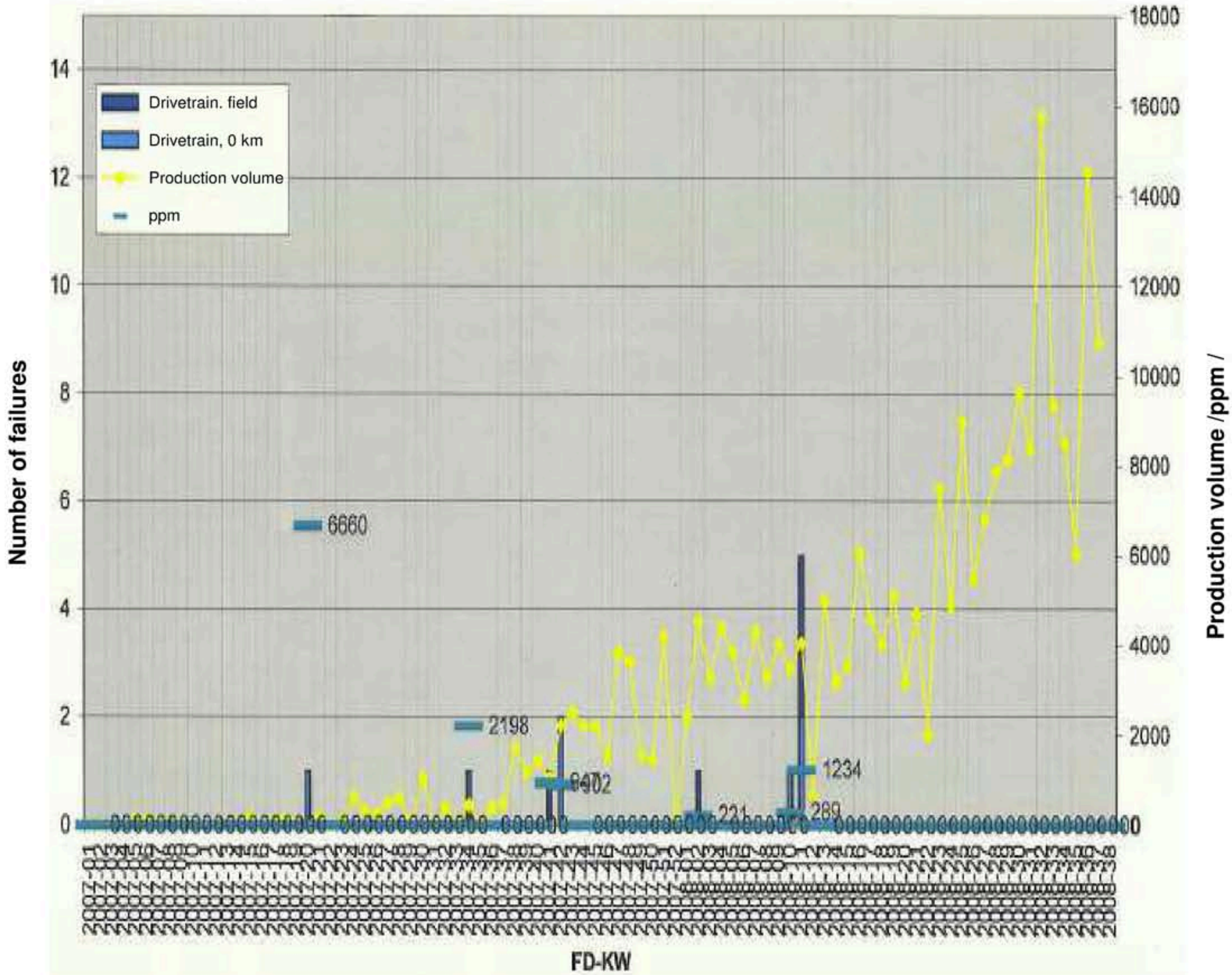
Drivetrain damage VW/Audi CP4.1(-507/508)
0 km and field /FD-KW



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Appendix 11

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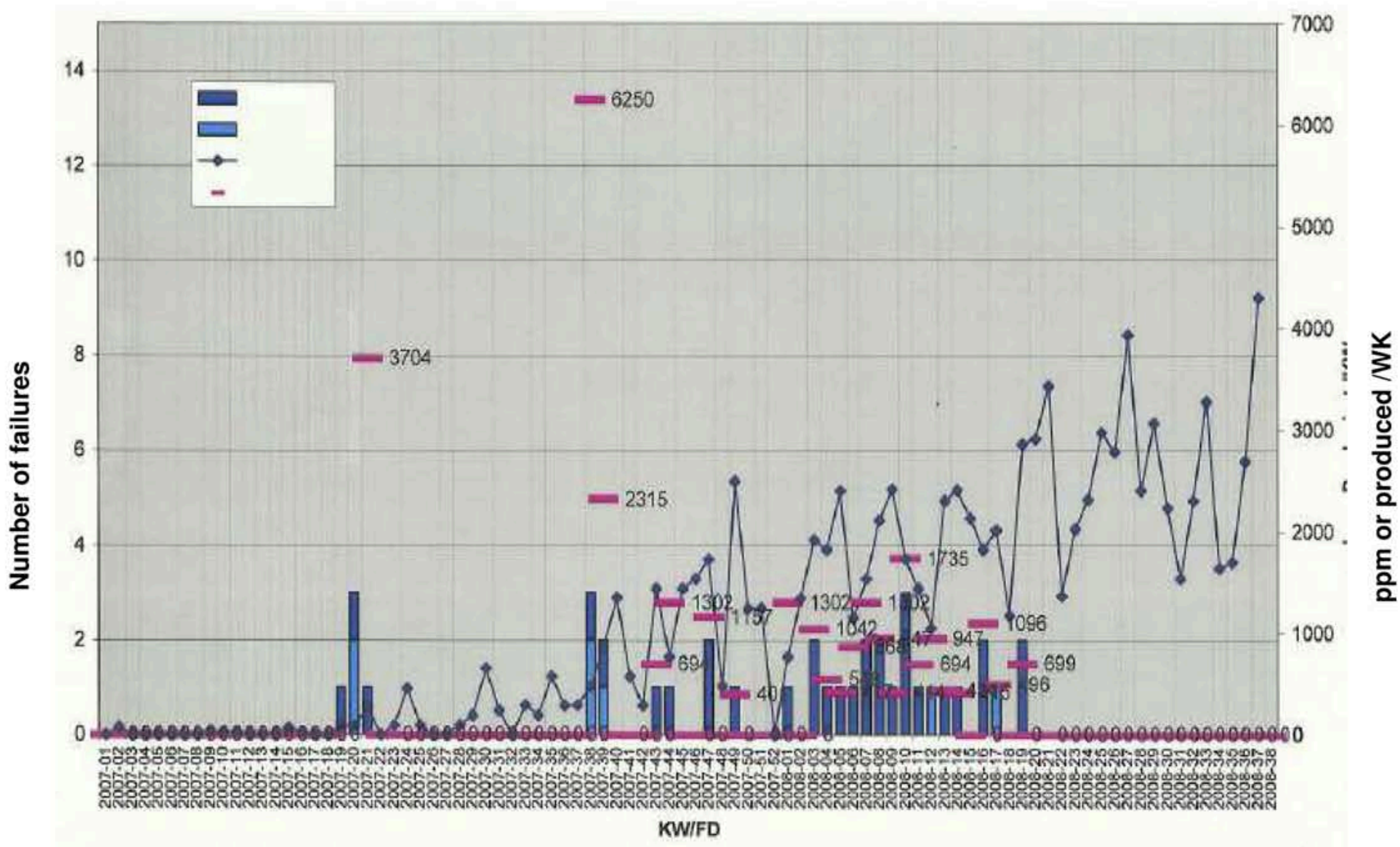
Status: 9/14/2008

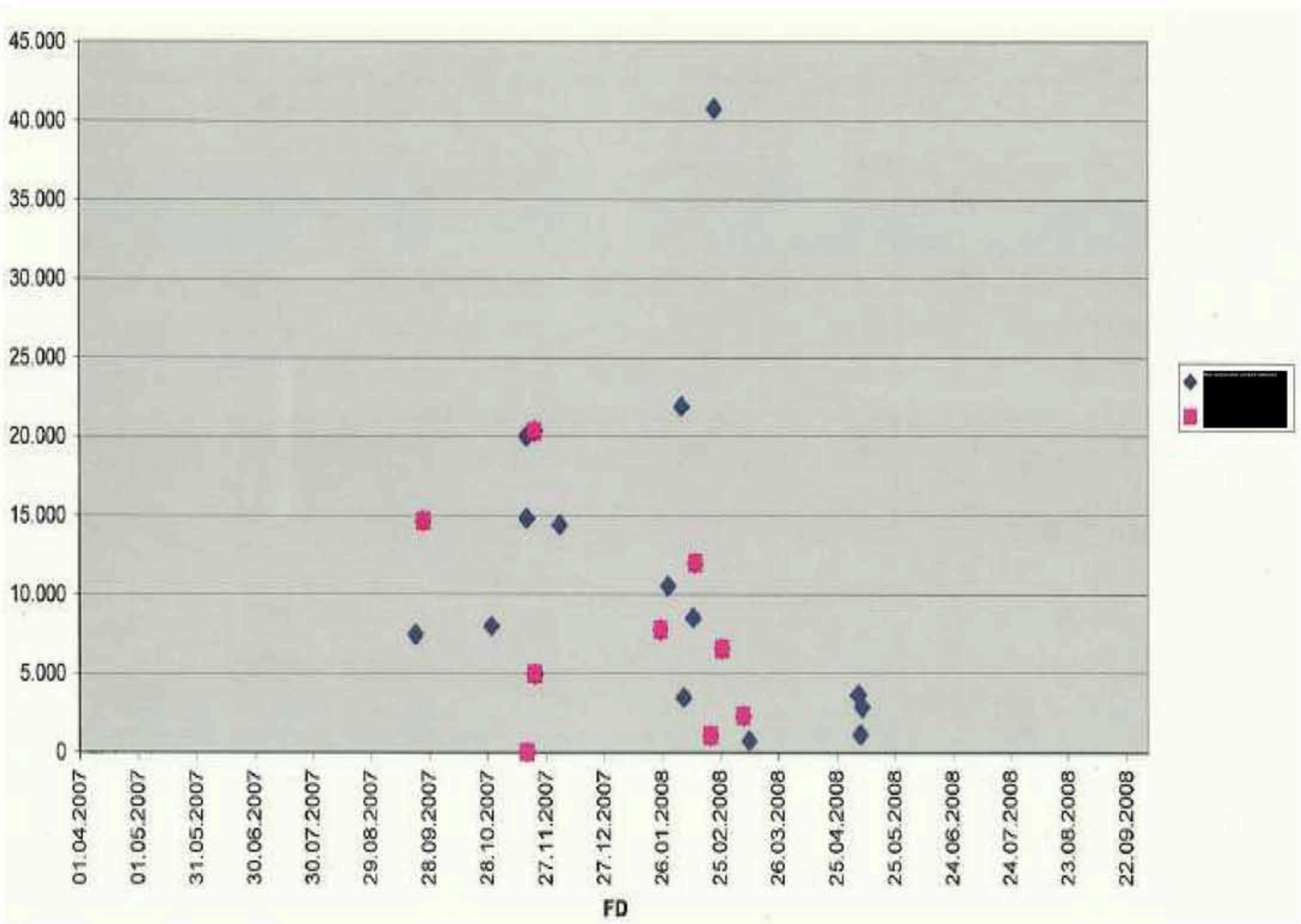
Drivetrain damage VW/Audi CP4.2 (-611/613)
0 km and field /FD-KW



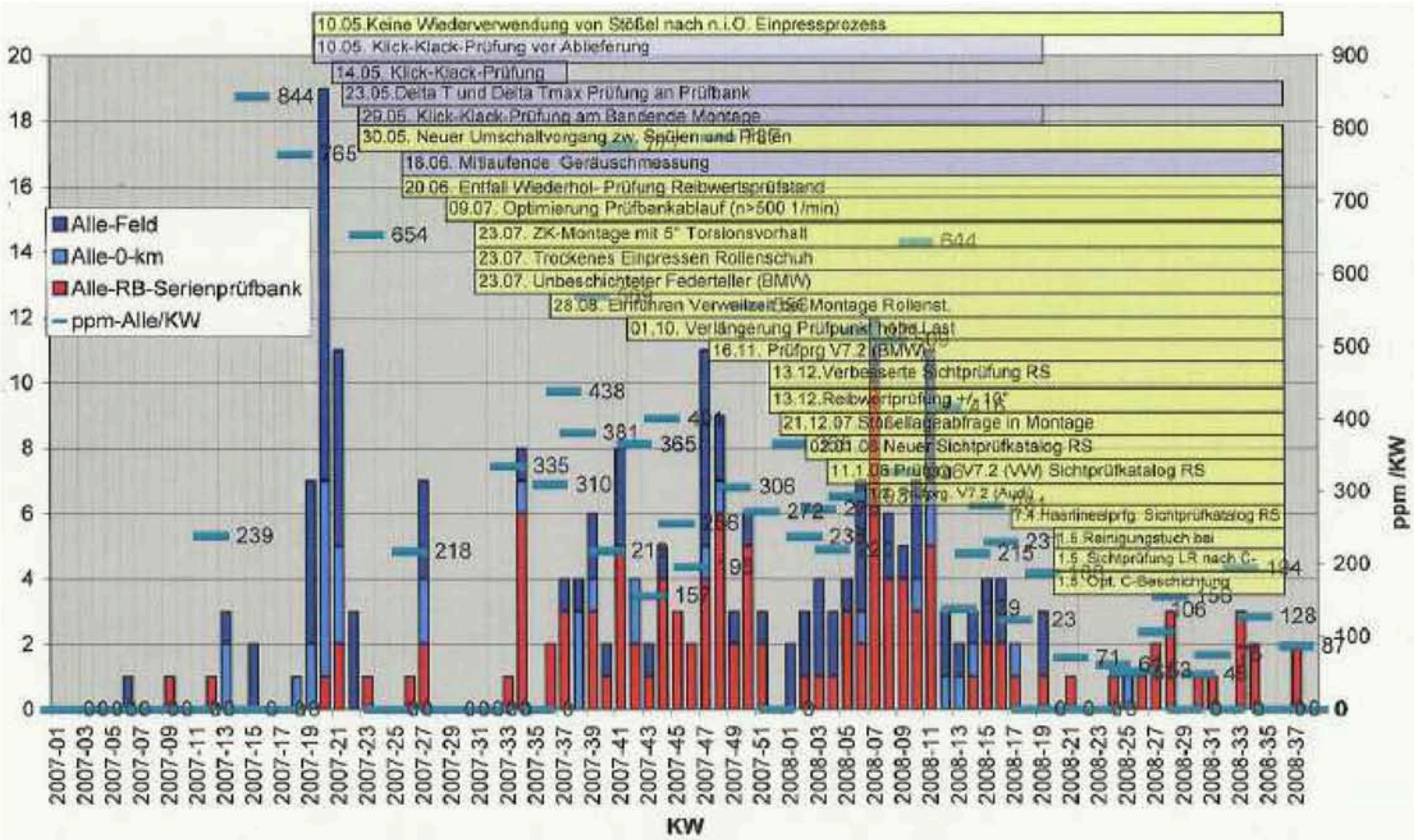
Appendix
11

Status: 9/14/2008

Drivetrain damage CP4.2 VW/Audi



Failures due to drivetrain damage FD-KW



All, field
All, 0 km
All RB series test bench
Ppm all/WK
10.05 No reuse of tappets if not OK Pressing process
10.05 Click-clack test
23.05 Delta T and Delta Tmax test of test
29.05 Click-clack inspection at the end of the assembly conveyor belt
30.05 New switching procedure between flushing and inspection
18.06 Continuous noise measurement
20.06 Repeat inspection on frictional coefficient test bench dropped
09.07 Optimization of test bench process optimized (n>500 1/min)
23.07 CH assembly with 5^{0} torsion
23.07 Dry pressing in of roller shoe
23.07 Uncoated spring plate (BMW)
28.08 Introduction of dwell time in assembly, roller
01.10 Extension of checkpoint heavy load
16.11 Inspection V7.2 (BMW)
13.12 Improved visual inspection, RS
13.12 Frictional coefficient check +/- 10^{0}
12/21/2007 Tappet check in assembly
1/2/2008 New visual test catalog, RS
1/11/2008 Inspection V7.2 (VW) visual test catalog, RS
Inspection V7.2 (Audi)
7.4 Straightedge test CP4.2 visual inspection catalog, RS
1.5 Cleaning cloth with
1.5 Visual inspection LR for C
1.5 Opt. C coating

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Status: 9/14/2008

Task force activities to reduce power train failures

1. 1) Metalization on roller shoe (RS)

1.1) Prevention of metalization

Graphite/boron nitride covering on holders in C layer coating system

- Test new system — done
- 2-day production/major test planned — T. under discussion
- If test is positive, introduction planned — T. under discussion

1.2) Detection of metalization

- Feasibility study for objective measurement processes — done
- Two quotations for camera monitoring in progress, major trial under series conditions required for evaluation purposes (avoidance of pseudo scrap)
- Ordering of preferred solution for 1st line in FeP planned by WK 44, implementation then expected by 04.09.
- 2 visual inspections used at present (after finishing or frictional coefficient test)

Task force activities to reduce power train failures

3) Avoidance of C layer removal during washing/ transport, RS

New washing/ transport frame

- first 100 — done
- Complete changeover — ~~WK 40~~→WK 42

3.1) Avoidance of C layer removal during pressing, RS in tappet body SK

- Peeling particles of from the C layer on RS are transferred during frictional coefficient measurement and can lead to early damage. The following potential remediation measures are currently being assessed:
    - Optimization of C-layer adhesion
    - Avoiding C-layer
- Draw up a schedule for further procedures — WK39

Activities to reduce drivetrain failures

Task force activities to reduce power train failures

Activities involving transfer of C particles to roller show - further action

1. Analysis of a rail system set (480) prior to the pressing process ➔identify peculiarities, observe flow, and take a closer look at anomalies, flow under the microscope	WK 40
2. Feasibility assessment of "brushing" rail system surface (after applying C layer)	WK 44
3. Analysis of the C layer ridge found. Implementation of an FIP section	Wk 43
4. Change to RS retaining tool when inserting the tappet body →smaller support surface, better coverage	WK 48
5. Feasibility study for omitting coating on RS surface	Wk 48

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Activities to reduce drivetrain failures

4) Avoiding "fusing" on cam roller.

Currently there are two solution approaches being considered:

- a) Improvement of cam roller contact through resilient contact plate
- b) direct alignment of the rollers ("stack of wood") for improved contact

- b) is favored and prioritized; if effect is positive implementation by Wk 48

- Currently there are 2 x straightedge tests used to positive effect, since in the second test no faulty parts were found.

5) Change to construction layout

- Change to layer system, cam roller camber from C3 to C2 (testing W24 D4, VW package 3)
- Improved tight fit for the roller shoe/tappet body press assembly R.B. internal testing

WK 43

BOSCH

Replication operation with non-OK rollers

Topic

Confirmation of failure hypothesis for "export countries"
"Drivetrain damage due to combination of stiff cam roller (in this instance, fusing on the cam roller) in combination with country-specific peculiarities(in this instance, fuel)" **through a replication test**

Implementation (0445010**613** instead of 0445010**611** due to C-coated piston to prevent piston seizure) CP4.2 W19 BIN5 with melt on the cam rollers (waste from straightedge test; subsequent frictional value test OK) set up and operated with poorly lubricating fuel GDK650 (HFRR 650 µm).

Result
Drivetrain damage after 35 hours of operation

Note
The **drivetrain** task force carried out several similar tests with EN590, although only one case of drivetrain damage occurred.

Conclusion
Result confirms the **failure hypothesis**. Pumps manufactured prior to the introduction of the straight-edge test (7.04.2008) can--in combination with poor lubricity--experience failures.

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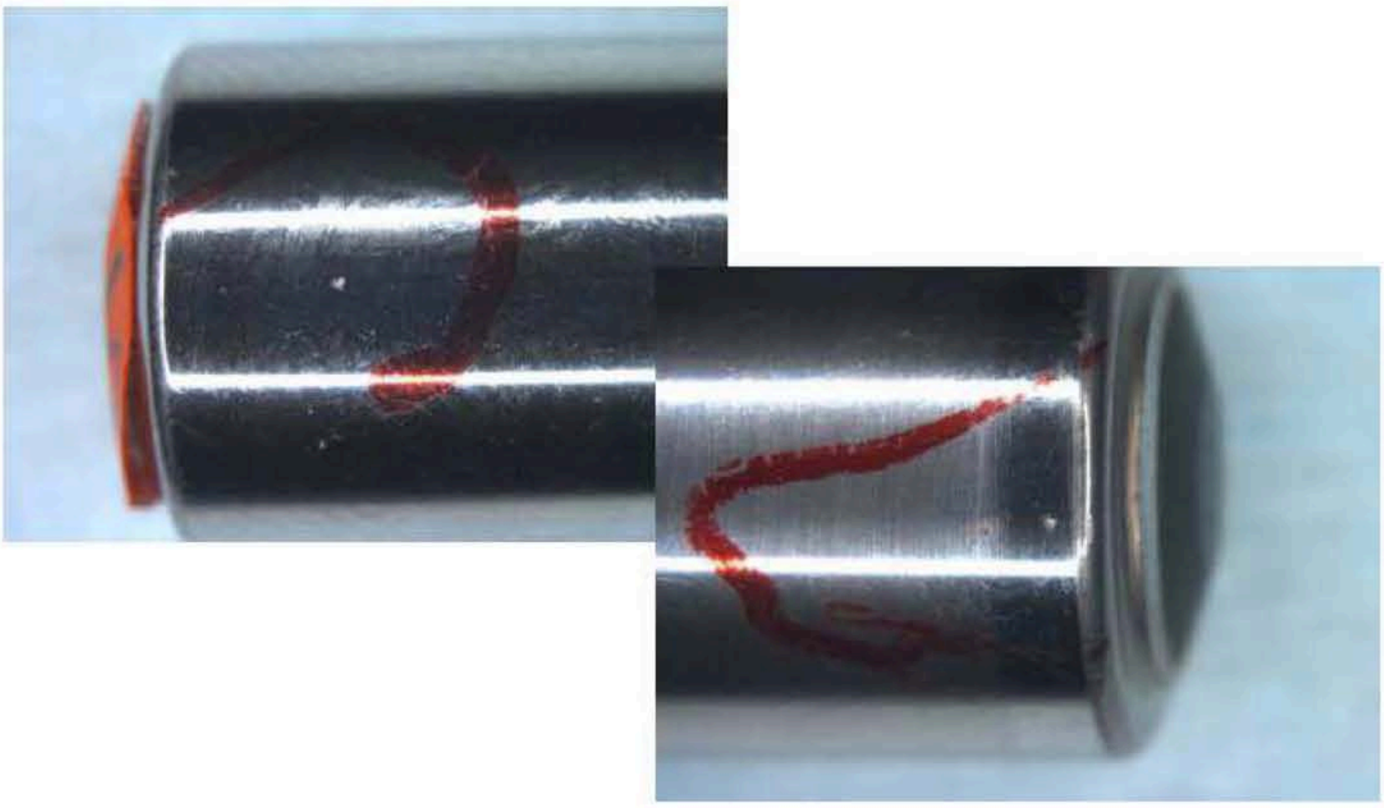
Provocative operation with non-OK rollers

Photos of roller before continuous test



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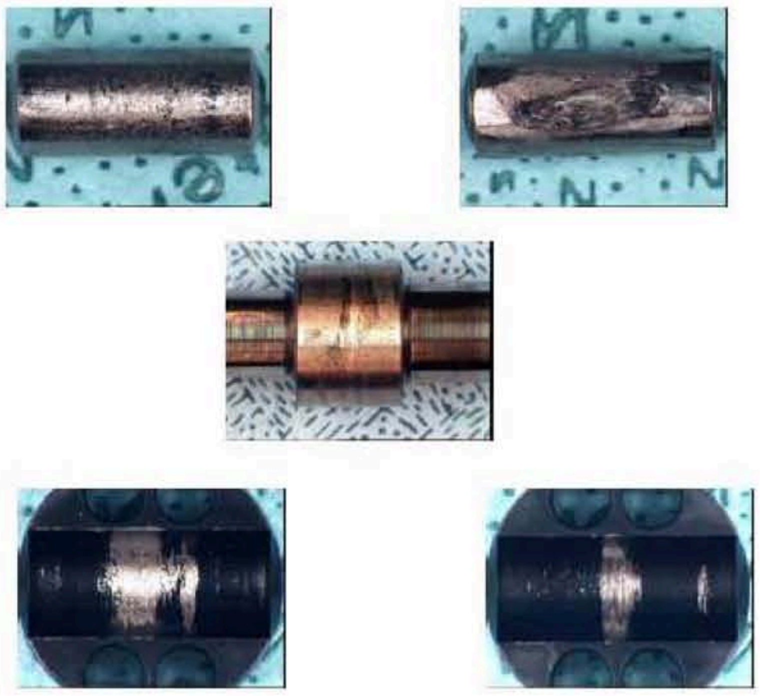
Provocative operation with non-OK rollers

Photos after continuous test



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Activities to reduce drivetrain failures

Development activities to reduce drivetrain failures

(focus on export countries [redacted])

Failure hypothesis:

Drivetrain damage due to combinations of stiff cam roller (slippage in production prior to introduction of the straightedge test, etc. 1.05.2008) + country-specific special features (fuel, transport, commissioning)

1) KT analysis with key question

[redacted]

- Why is the failure rate in [redacted] higher than in [redacted]
- Why is CP4.2 affected more than CP4.1 (production plant, components,…)

Activities to reduce drivetrain failures

2) Investigation in relation to fuels and special fuel features in export markets

2.1) Water

Estimate: Unlikely, but one pump found with visible signs signs of corrosion
2.1.1) Action: Replication attempt with sloshing water
Result: no drivetrain damage, slight traces of tarnishing in housing
2.1.2) Action: Replication attempt with continual water entry
Result: drivetrain damage
2.1.2) Action: WCF test with 1% water & subsequent continuation with EN590
Result: will be presented 29.09.2009.

2.2) Fuel from [redacted]

Estimation: probably in combination with other influencing factors
(influence of special feature of fuel, steroyl glucosides unlikely)
2.2.1) Action: Obtain fuel samples from failure map **Date 10.24.08**[redacted]
Result:
2.2.2) Action: Analysis of fuel from faulty pumps **Date ongoing V. Audi,** [redacted]
Result: No striking features to date

Activities to reduce drivetrain failures

2.3) Fuel from [redacted]

Estimation: probably in combination with other influencing factors
2.3.1) Action: Provocative operation with non-OK Roller & GDK650
Result: Failure after 35 hours with final turned tappet
2.3.2) Action: Continuous replication testing with OK cam roller & GDK650, **Date CW 41 V. [redacted]**
but with stiff cam roller (friction testing committee)
Result:
Other continuous tests planned and pumps currently being set up)

2.4) Air in fuel

Assessment: Unlikely
(air found in pump inlet during vehicle measurement (Leasing Q7))
2.4.1) Action: Replication test with high air proportion
Result: no power train damage, but high degree of foam formation
2.4.2) Action: Research with Audi series electric fuel pump & filter
Result: Inline electric fuel pump can take in air via the filter
Recommendation: Verify NDKL layout design with borderline components. **V. Audi**
2.4.3) Action: Continuous test with defined air input **Date CW 42 V. [redacted]**
Continuous testing in combination with 'minimum' belt tension (determined on the Engine

Activities to reduce drivetrain failures

2.5) Other special features of fuel

Action: Analysis of fuel deposits **Date 09.29.2008** [redacted]

Result: Only one unusual pump. Rust, products from aging fuel & traces of chlorine and silicone oxide. The source corrosion medium (probably containing chlorine) could not be found. Other faulty pumps will be examined.

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Drivetrain damage in CP4 high-pressure fuel pump

Keyword - Failure location	Failure country	Veh. no.	Part no. Audi/VW	RB no.	QTS-/ AV3 no.	IQIS no.	QMM3 pump in FeP	Task force no.	Failure location: Field	Sampling Q-AL	Veh. plant	Hot test	Cold test	Veh.: VW	AU	Veh. plant: Non-responsive content removed								Engine: R4	V6 2,7l	V6 3.0l	V6 3.0l BIN5	Pump plant: FeP	JhP	ML pump: ML1	ML2	ML3	ML4	FD Pump	FD Veh.	Reg. Date	Date Failure/ Rep.	Mileage	Roller Noguchi Güntert	Roller right 2 pistons only	Additional information: Comment / complaint	Cat.	Fuel test	Result of frictional coefficient test	Result of findings / comment
Worldwide unit volume of SOP - WK 26/08																615	95.716		10.460	?	?	?	19.344	92.377	18.516	19.344	?																		
Non-responsive content removed	Non-responsive content removed		03L 130 755	.507	AV3 1180937	BSA000001209-001	4VW09						[redacted]											[redacted]				FeP		01-0055				20.10.2007				0	Nog.	-	Rail pressure too high (VW cold test) particles in HPFP				
			03L130 755	.507	AV3 1180937	BSA000001210-001	4VW10																					FeP		01-0595				15.10.2007				0	Nog.	-	Rail pressure too high (VW cold test) particles in HPFP				
			03L 130 755	.507	2943784	WIA000001838-001	4VW80	210																				FeP		01-0260				05.03.2008				0	Nog.	-	Zajos nem termel nyomást	1			
			03L 130 755	.507	2949867	WIA000001840-001	4VW81	211																				FeP		01-0540				11.03.2008				0	-	-	Noise Pressure not OK	1			
			03L 130 755	.507	2949867	WIA000001840-002	4VW82	212																				FeP			02-0272			10.03.2008				0	Nog.	-	Noise Pressure not OK	1			
			03L 130 755 A	.508	?	IGH000000105-001	4VW02	49				X																FeP		01-0456				15.05.2007				0	Nog.	-	Fuel pressure flow increases to about 8 bar after the start within about 15 seconds (maximum shaft brake)	1			
V6 test facility		Engine CAR003060	059 130 755 AB	.611	2801936	WIA000001637-001	4VW09	149				X														X		FeP		01-0901				9/28/2007				0	Nog.	Nog.	The necessary pressure cannot be established	1			
CP7		Engine CAS022611	059 130 755 AB	.611	2969671	WIA000001679-001	4A13	234			X				X								X			X		FeP		01-0078				19.03.2008				0	Nog.	Nog.	No fuel pressure	1			
CP7		Engine CBE003127	03L 130 755 A	.508			4VW104				X			X						X				[redacted]				FeP			02-0049			30.03.2008				0	?	-	Breakdowns on roller	1	OK	OK	Residual fuel in analysis until 12.09 Flange bearing corrode particles
CP7			059 130 755 AB	.611	3117174	WIA000002060-001	4A73				X				X								X			X		FeP		01-0010				07.07.2008				0			High-pressure pump drivetrain damage		OK		
Non-responsive content removed			059 130 755 AB	.611	AV3 1148290	BSA000001162-001	4A02	59			X			X								No sufficient prior filling CP7				X		FeP		01-0416				14.05.2007				0	Nog.	Nog.	Particles in injector (delivered in disassembled state)	1			
			059 130 755 AB	.611	AV3 1148290	BSA000001162-002	4A03	60			X			X												X		FeP		01-0392				14.05.2007				0	Nog.	Nog.	No CP4.2 conveyed volume	1			
			059 130 755 AB	.611	2799632	WIA000001635-001	4A07	116			X			X												X		FeP		01-0076				20.09.2007				0	Nog.	Nog.	Malfunction: probably twisted tappet	1			
			059 130 755 AB	.611	2814871	WIA000001679-001	4A08	151			X			X												X		FeP		01-0068				20.09.2007				0	Nog.	Nog.	Engine will not start. High-pressure pump function	1			
VW Jetta testing	USA	GQG-1K59M029	03L 130 755 A	.508	AV3 1220982	BSA000001229-001	4VW77	209		X				X						X				[redacted]				FeP		01-0119				23.08.2007			10.03.2008	23.927	-	-	Particles in fuel system, malfunction	t.b.d.			Hypothesis: Ridge on cam roller/ metallization on C layer
Q-AL IN Audi A3	[redacted]	8P281000225	03L 130 755	.507	2973772	IGE000001819-001	4VW87	233		X					X	X												FeP		01-0156				12.10.2007			19.03.2008	15.425	Nog.	-	Rail pressure sporadically not reached	4			Poor quality fuel!!!
Q-AL Q7 BINS 1. Case	USA	AU716 9 8018	059 130 755 AG	.613	—			246		X					X								X				X	FeP		01-0626				30.11.2007				40.000	Nog.	-	Engine died while driving at constant speed	1			W19 tension roller instead of W24
Q-AL Q7 BINS 2. Case	USA	AU716 9 8017	059 130 755 AG	.613	—					X					X								X				X	FeP		01-0633				30.11.2007				62.300	Nog.	-	Cardown	1			W19 tension roller instead of W24
(Q-AL Q7 BIN5 repeat repair)	USA	AU716 9 8017	059 130 755 AG	.613	—					X					X								X				X	FeP		01-0388				05.06.2008				6.800	-	-	Veh. mileage 69,100 km	-			No drivetrain damage, UM and OV sleve with black particles
Q-AL Touareg BIN5	USA	7L69D024	059 130 755 AG	.613	—					X					X								X				X	FeP		01-0900				22.01.2008				2.723	Nog.	-	Vehicle will not start	1			24 tension roller
Non-responsive content removed	Non-responsive content removed	3GZ88000673	059 130 755 AB	.611	33755/01	IGH000000402-001	4A19	250	X					X								see above				X		FeP		01-0314				24.05.2007		13.09.2007	26.02.2008	11.027	Nog.	Nog.	Engine will not start	1			
		8K58A001297	059 130 755 AB	.611	3014805	IGG000002470-002	4A20	260	X						X		X								X			FeP		01-0268				21.09.2007		—	17.04.2008	7.486	-	-	[redacted]	5			???
		8T68A038805	059 130 755 AB	.611	3081153	IGG000002702-001	4A29		X						X				X						X			FeP		01-0249				11.03.2008	29.03.2008	25.04.2008	09.06.2008	744	Nog.	Nog.	Electrical fault	1	OK		WK 29 to Bosch
		4LX8D036043	059 130 755 AB	.611	3081141	WIA000002031-001	4A46		X						X								X			X		FeP		01-0708				30.10.2007	—	18.12.2007	11.06.2008	8.000	Nog.	Nog.	Non-responsive content removed	1			
		8K68N010292	059 130 755 AB	.611	3094642	IGE000001961-001	4A30		X						X			X							X			FeP			02-0641			29.01.2008	22.02.2008	31.03.2008	09.06.2008	10.561	Nog.	Nog.		1			
		8T48A037796	059 130 755 AB	.611	3096142	IGC000000953-001	4A44		X						X				X						X			FeP			02-0438			07.05.2008	25.03.2008	24.04.2008	07.07.2008	1.123	Nog.	Nog.		1	OK		
		8K59N001228	059 130 755 AB	.611	3105630	IGG000002812-001	4A64		X						X			X							X			FeP			02-0346			06.05.2008	28.05.2008	03.07.2008	04.08.2008	3.641	Nog.	Nog.	Mechanical fault		OK		
		8T98A033470	059 130 755 AB	.611	3102978	IGG000002783-001	4A58		X						X				X						X			FeP			02-0676			06.02.2008	23.02.2008	28.03.2008	5/20/2008	3.470	Nog.	Nog.	Electrical fault	1	OK		
		4L68D056306	059 130 755 AB	.611	3102986	IGG000002783-003	4A60		X						X								X			X		FeP		01-0004				22.02.2008	—	05.05.2008	7/22/2008	40790 1006 ?	Nog.	Nog.	Non-responsive content removed	2	OK		
		8K88N002761	059 130 755 AB	.611	3105738	IGG000002812-003	4A66		X						X			X							X			FeP		01-0265				04.12.2007	11.01.2008	20.03.2008	17.07.2008	14.407	Nog.	Nog.	Mechanical fault	1			
		8T98A023540	059 130 755 AB	.611	3107457	IGG000002812-002	4A65		X						X				X						X			FeP		01-0762				15.11.2007	—	—	18.07.2008	6.231	Nog.	Nog.	Mechanical fault	-	OK		Pump OK
		8T08A023636	059 130 755AB	.611	3127768	IGG000002876-003	4A76		X						X				X						X			FeP		01-0378				17.11.2007	—	09.01.2008	27.08.2008	14.838	Nog.	Nog.	Filter + fuel	1			
		8K38N012422	059 130 755 AB	.611	3127772	IGG000002876-001	4A78		X						X			X										FeP			02-0905			11.02.2008	—	08.04.2008	18.08.2008	8.531	Nog.	Nog.					
		8K29A029401	059 130 755 AB	.611	3127802	IGG000002876-004	4A79		X						X		X									X		FeP			02-0994			08.05.2008	—	26.06.2008	04.08.2008	2.882	Nog.	Nog.	Fuel				
		4LX8D039881	059 130 755 AB	.611	3127745	IGG000002876-002	4A77		X						X								X			X		FeP		01-0167				17.11.2007	—	25.01.2008	20.08.2008	20.063	Nog.	Nog.	Filter + fuel		OK		
		4L98D058437	059 130 755 AB	.611	3045046	WIH000000324-001	4A24	275	X						X								X			X		FeP			02-0447			06.03.2008	27.03.2008	09.04.2008	03.06.2008	6.875	Nog.	Nog.	Particles in fuel filter	1			
		4L98D058437	059 130 755 AB	.611	3108206	DCD000003720-001	4A57		X														X			X		FeP			02-0485			08.05.2007	—	09.04.2008	31.07.2008	13.581	Nog.	Nog.	Vehicle will not start	1	OK		Tension roller incorrectly installed
		4L78D048795	059 130 755 AB	.611	3089357	WIA000002030-001	4A45		X						X								X			X		FeP		01-0062				16.01.2008	—	18.04.2008	30.06.2008	3479	Nog.	Nog.		1			
		4L68D042017*	059 130 755 AB	.611	3124575	IGG000002871-001	4A74		X						X								X			X		FeP		01-1108				15.01.2008	—	27.03.2008	25.08.2008	5.352	Nog.	Nog.	WK 37 to Bosch				
		4L68D042017*	059 130 755 AB	.611	3124575	IGG000002871-002	4A75																					FeP		01-0053				03.12.2007		27.03.2008?	25.08.2008?	53527	Nog.	Nog.					
		8T38A036218	059 130 755 AB	.611	3100762	IGG000002768-004	4A53		X						X				X						X			FeP			02-0026			20.02.2008	—	15.07.2008	28.07.2008	1.044	Nog.	Nog.	Vehicle will not start	2	under analysis		
		7LZ8D045761	059 130 755 AB	.611	3103651	WIH000000367-001	4A48		X						X								X			X		FeP		01-0232				17.11.2007	—	08.02.2008	22.07.2008	n/a	Nog.	Nog.	Engine will not start	1			
		4L18D041101	059 130 755 AB	.611	3100802	IGG000002768-003	4A52		X						X								X			X		FeP		01-0046				21.11.2007	—	19.02.2008	25.07.2008	4.961	Nog.	Nog.	Vehicle will not start	1	under analysis		
		4L88D041225	059 130 755 AB	.611	3095199	IGE000001962-001	4A31		X						X								X			X		FeP		01-0045				21.11.2007	—	15.01.2008	03.07.2008	20.395	Nog.	Nog.	Fuel analysis report 20/08-1			OK	
		4L58D053753	059 130 755 AB	.611	3100810	IGG000002768-007	4A56		X						X								X			X		FeP			02-0303			12.02.2008	—	01.04.2008	16.07.2008	11.975	Nog.	Nog.	Vehicle will not start	2	OK		
		8T58A036253	059 130 755 AB	.611	3100782	IGG000002768-002	4A51		X						X				X						X			FeP			02-0638			26.02.2008	—	07.04.2008	16.07.2008	6.566	Nog.	Nog.	Follow-up engine damage !!!	1	under analysis		
		8T48A018326	059 130 755 AB	.611	3100822	IGG000002768-006	4A55		X						X				X						X			FeP		01-0004				25.09.2007	—	09.01.2008	10.07.2008	14.633	Nog.	Nog.	Vehicle will not start	1	under analysis		
		8T48A039614	059 130 755 AB	.611	3100777	IGG000002768-001	4A50		X						X				X						X			FeP		01-0075				08.03.2008	—	22.05.2008	24.07.2008	2.290	Nog.	Nog.	Vehicle will not start	1	under analysis		
		8T48A031500	059 130 755 AB	.611	3100816	IGG000002768-005	4A54		X						X				X						X			FeP		01-0595				25.01.2008	—	01.03.2008	22.07.2008	7.774	Nog.	Nog.	Vehicle will not start				
		4L78D065466	059 130 755 AB	.611	3104714	IGG000002783-004	4A61		X						X								X			X		FeP			02-0612			19.04.2008	—	29.05.2008	07.07.2008	1.695	Nog.	Nog.	Electrical fault	1			
		4LX8D052338	059 130 755 AB	.611	3104709	IGG000002783-002	4A59		X						X								X			X		FeP			02-1041			11.02.2008	—	29.02.2008	09.06.2008	4.154	Nog.	Nog.	Mechanical fault	1	OK		
		4L78D065662	059 130 755 AB	.611	3104944	IGG000002783-005	4A62		X						X								X			X		FeP		01-1135				14.04.2008	—	28.05.2008	11.07.2008	4.496	Nog.	Nog.	Electrical fault	1	OK		
		4L08D050954	059 130 755 AB	.611	3143299				X						X								X			X		FeP								—	—	?			with fuel test				
		8K39A063346	059 130 755 AB	.611	3106532	IGG000002804-001	4A63		X						X		X								X			FeP			02-0745			28.06.2008		Without	29.07.2008	12	Gün.	Gün.	Engine will not start	-	OK	OK	Pump OK
		8K98A032732	059 130 755 AB	.611	2981499	IGE000001824-001	4A14	235	X						X		X								X			FeP			02-0752			03.03.2008	—	08.04.2008	14.04.2008	6	Nog.	Nog.	[redacted]	1			
		8T98A041438	059 130 755 AB	.611	3037238	IGG000002557-001	4A22		X						X				X						X			FeP		01-0394				27.03.2008	16.04.2008	28.04.2008	28.04.2008	300	Nog.	Nog.	Vehicle stopped				
		8K98N024347	059 130 755 AB	.611	3047167	IGG000002610-001	4A26		X						X			X							X			FeP			02-0570			05.04.2008	—	09.05.2008	05.06.2008	2.764	Nog.	Nog.	Glow plug system activated while traveling on motorway				
		8T58A022118	059 130 755 AB	.611	3099371	IGG000002767-001	4A49		X						X				X						X			FeP		01-0372				27.10.2007	30.11.2007	07.12.2007	23.06.2008	5.473	Nog.	Nog.	Vehicle will not start	1	under analysis		
		7LZ8D057265	059 130 755 AB	.611	3101070	WIA000002035-001	4A47		X						X								X			X		FeP		01-0728				16.01.2008	—	07.03.2008	10.06.2008	18985	Nog.	Nog.	Engine will not start, cardown	1	OK		Corrosion: warranty rejected
		8T78A030714	059 130 755 AB	.611	3118659	IGG000002864-002	4A71		X						X				X						X			FeP		01-0102				03.01.2008	07.02.2008	27.02.2008	06.08.2008	14.030	Nog.	Nog.	Dispatch 08.09 Vehicle will not start, but engine turning over		under analysis		
		8T58A030355	059 130 755 AB	.611	3121541	IGG000002864-003	4A70		X						X				X						X			FeP		01-0868				18.01.2008	07.02.2008	20.02.2008	10.07.2008	6.140	Nog.	Nog.	Dispatch 08.09 Engine failed while driving and will not start		under analysis		with fuel test
		8K78N024251	059 130 755 AB	.611	3143722				X						X			X										FeP							22.04.2008	09.05.2008	19.06.2008	5.168							
		8T48A038351	059 130 755 AB	.611	3123210	IGG000002863-001	4A69		X						X				X						X			FeP			02-0156			02.03.2008	27.03.2008	25.06.2008	02.07.2008	86	Nog.	Nog.	Mechanical fault	-			Pump OK
		8K18A035821	03L 130 755	.507	3016558	IGG000002470-001	4VW93	259	X						X		X							Non-responsive content removed				FeP		01-0349				12.03.2008		17.04.2008	05.05.2008	1.584	-	-	Glow filament lights up, vehicle stopped and will not restart	-			Not typical drive-train damage Cause of failure: tappet spring broken
VW Tiguan		5NZ8W036616	03L 130 755	.507	QT80288	BSA000001258-001	JhP		X					X						X									JhP			03-152		22.01.2008		—	05.05.2008	3.452	Nog.	-	Engine died while driving				6.7% RME, not the cause of drivetrain damage
Non-responsive content removed	[redacted]	8K48N006273	03L 130 755	.507	2974476	IGE000001820-001	4VW86	232	X						X			X						[redacted]				FeP		01-0800				11.01.2008	—	26.03.2008	26.03.2008	25	Nog.	-	Non-responsive content removed	2			
		8KX8N002048	03L 130 755	.507	3031672	IGC000000945-001	4VW95		X						X			X										FeP		01-0261				05.11.2007	20.12.2008	08.02.2008	27.05.2008	4.057	Nog.	-					
		8K58A037278	03L 130 755	.507	3051740	IGG000002594-001	4VW97	274	X						X		X											FeP			02-0328			15.03.2008	03.04.2008	04.04.2008	24.04.2008	814	Nog.	-	Engine will not start.	2			
		8K68A039265	03L 130 755	.507	3070039	IGG000002672-001	4VW99		X						X		X											FeP			02-0086			15.03.2008	10.04.2008	06.05.2008	04.07.2008	4.682	Nog.	-	Electrical fault	2	OK		WK 29 to Bosch
		8K88N022279	03L 130 755	.507	3118777				X						X			X																	15.04.2008	16.04.2008	28.07.2008	20.422			Dispatch 08.09				with filter (run dry)
		8K58A025082	03L 130 755	.507	3131203	IGG000002877-001	4VW114		X						X		X											FeP			02-0341			05.02.2008	—	05.04.2008	02.06.2008	21.921	Nog.	-	Pump sent to Bosch 15.09		OK		
Parts unavailable 6 cyl. 2.7l / 3..0l																																													
Non-responsive content removed	Non-responsive content removed	8T08A032210	059 130 755 AB	.611	A5 2,7L TDI	not delivered			X						X				X						X			FeP								18.03.2008	4/15/2008	434							
		8T58A036673	059 130 755 AB	.611	A5 2,7L TDI	not delivered			X						X				X						X			FeP								09.04.2008	6/2/2008	1.462							
		8K88N011315	059 130 755 AB	.611	A4 2,7L TDI	not delivered			X						X			X							X			FeP								02.04.2008	4/24/2008	1.687							
		8K88N011508	059 130 755 AB	.611	A4 2,7L TDI	not delivered			X						X			X							X			FeP								28.03.2008	5/20/2008	2.000							
		8K48N026913	059 130 755 AB	.611	A4 2,7L TDI	not delivered			X						X			X							X			FeP								07.05.2008	6/10/2008	850							
		4L48D050620	059 130 755 AB	.611	Q7 3,0L TDI	not delivered			X						X								X			X		FeP								13.02.2008	5/20/2008	454							
		4LX8D059368	059 130 755 AB	.611	Q7 3,0L TDI	not delivered			X						X								X			X		FeP								13.05.2008	5/19/2008	130							
		4L98D052833	059 130 755 AB	.611	Q7 3,0L TDI	not delivered			X						X								X			X		FeP								25.04.2008	6/18/2008	2.665							
		7LZ8D044505	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								13.02.2008		3.000							
		7LZ8D048650	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								07.02.2008		10.426							
		7LZ8D072828	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								16.05.2008		3.386							
		7LZ8D042792	60 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								20.12.2007		15.592							
		7LZ8D072161	61 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								02.06.2008		3.908							
		7LZ8D043956	62 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								04.01.2008		12.422							
		4L98D048085	059 130 755 AB	.611	Q7 3,0L TDI	not delivered			X						X								X			X		FeP		01-1108				15.01.2008			6/10/2008								
		4L98D012325	059 130 755 AB	.611	Q7 3,0L TDI	requested			X						X								X			X		FeP										200							
		4LX8D052548	059 130 755 AB	.611	Q7 3,0L TDI	not delivered			X						X								X			X		FeP									4/25/2008								
		8T08A045409	059 130 755 AB	.611	A5 2,7L TDI	requested			X						X				X						X			FeP		01-0429				07.07.2008		30.05.2008	01.09.2008	3.324							
		4L27D075465	059 130 755 AB	.611	Q7 3,0L TDI	Part + fuel requested 7/30/2008		173	X						X								X			X		FeP			02-0303			12.02.2008		01.04.2008	17.07.2008	11.975	Nog.	Nog.		2			
		4LX8D059760	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L08D046354	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L18D044077	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L18D058416	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L28D043245	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L38D053931	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L78D043225	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L48D058099	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L78D041653	059 130 755 AB	.611	Q7 3,0L TDI				X						X								X			X																			
		4L58D051002	059 130 755 AB	.611	Q7 3,0L TDI	30.07.2008			X						X								X			X		FeP			02-0310			02.02.2008		05.03.2008	15.07.2008	8.706							
		8K78A022720	059 130 755 AB	.611	unknown				X						X		X																												
		8TX8A034465	059 130 755 AB	.611	A5 2,7L TDI				X						X				X						X																				
		8T28A031785	059 130 755 AB	.611	A5 2,7L TDI				X						X				X						X																				
		8T58A026337	059 130 755 AB	.611	A5 2,7L TDI				X						X				X						X																				
		8T28A015568*	059 130 755 AB	.611	A5 2,7L TDI	1 failure			X						X				X						X			FeP																	
		8T28A015568*	059 130 755 AB	.611	A5 2,7L TDI	2 failure requested 7/22/2008			X						X				X						X			FeP										16.471							
		7LZ8D051766	059 130 755 AB	.611					X					X									X			X		FeP								7.101									
		7LZ8D044864	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								21.896									
		7LZ8D046087	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								10.828									
		7LZ8D059328	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								4.590									
		7LZ8D068514	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP									16.07.2008	9.438							
		7LZ8D077002	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								6/20/2008		13.657							
		7LZ8D079271	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								16.07.2008		2.105							
		7LZ9D001269	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								29.07.2008		2.518							
		7LZ9D001482	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								7/10/2008		3.614							
		7LZ8D079271	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								16.07.2008		2.018							
		8K58A002031	059 130 755 AB	.611	A4 2,7L TDI	?			X						X		X								X			FeP								21.12.2007		13.662							
		8T48A028709	059 130 755 AB	.611	A5 2,7L TDI	?			X						X				X						X			FeP								15.02.2008		1.223							
		8T68A028422	059 130 755 AB	.611	A5 2,7L TDI	?			X						X				X						X			FeP								31.01.2008		6.062							
		8T48A038351	059 130 755 AB	.611	A5 2,7L TDI	?			X						X				X						X			FeP								25.06.2008		129							
		8T28A022021	059 130 755 AB	.611	A5 2,7L TDI	?			X						X				X						X			FeP								29.04.2008		12.800							
		4L88D052631	059 130 755 AB	.611	Q7 3,0L TDI	?			X						X								X			X		FeP								15.05.2008		1.131							
		4L98D054100	059 130 755 AB	.611	Q7 3,0L TDI	?			X						X								X			X		FeP			02-0784			13.02.2008		28.03.2008		18.691							
		4L78D041507	059 130 755 AB	.611	Q7 3,0L TDI	requested			X						X								X			X		FeP								31.12.2007	08.08.2008	26.931							
		7LZ8D067382	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								08.05.2008	11.06.2008	4.830							
		7LZ8D038732	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								11.12.2007	29.07.2008	20.737							
		7LZ8D049004	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								18.03.2008	04.08.2008	8.120							
		7LZ8D048789	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								28.12.2007	21.07.2008	27.137							
		7LZ8D076990	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								13.06.2008	05.08.2008	7.914							
		7LZ8D065032	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								25.03.2008	06.08.2008	4.065							
		7LZ8D072348	059 130 755 AB	.611	VW Touareg	not delivered			X					X									X			X		FeP								20.05.2008	07.07.2008	6.550							
		4L78D056296	059 130 755 AB	.611	Q7 3,0L TDI	Part + fuel delivered on 16.09.08			X						X								X			X		FeP		01-0370				28.02.2008		20.03.2008	15.09.2008	8.006							
4 cyl. 2.0l CR																																													
[redacted]	[redacted]	8K98A036067	03L 130 755	.507	A4 2.0 L TDI	Part requested WK22			X						X		X							[redacted]																					

[redacted]

[redacted]

EA11003EN-00006[1]

Only vehicle failures under testing and in the field

Model	Engine	Market	Failures	Delivery volume Vehicles SOP - June 08	Failure quota per mill.	Factor above average in worldwide comparison	Factor above average in comparison, [redacted]	Remark
Audi Q7	3.0l	worldwide	31	19.344	1,6	---		
		[redacted]	0	5.685	0,0			
		[redacted]	5	187	26,7	17	#DIV/0!	
		[redacted]	12	317	37,9	24	#DIV/0!	
		[redacted]	3	477	6,3	4	#DIV/0!	
		[redacted]	2	?				1 veh. 2 failures
		[redacted]	2	?				
		[redacted]	2	76	26,3	16	#DIV/0!	
		[redacted]	2	2.612	0,8			
		[redacted]	1					
		Q-AL USA	2	8	250,0	156	#DIV/0!	W19 tension roller instead of W24
Audi A4/A5	2.0l	worldwide	7	87.660	0,1			
		[redacted]	5	24.813	0,2			
		[redacted]	1	1.724	0,6	7	3	
		[redacted]	1	1.225	0,8	10	4	
	2.7l	worldwide	34	18.516	1,8			
		[redacted]	7	5.899	1,2			
		[redacted]	15	243	61,7	34	52	
		[redacted]	7	161	43,5	24	37	
		[redacted]	4	1.985	2,0			
		[redacted]	1	?				
	3.0l	[redacted]	2	?				
		[redacted]	1					
Audi A3	2.0l	[redacted]	1	---				Poor quality fuel!!!
VW Phaeton	3.0l	[redacted]	1	2.807	0,4			Late damage, poor ventilation in 06/07?
VW Touareg	3.0l	Free markets	26	13.266	2,0			
		[redacted]	1	4.780	0,2			
		[redacted]	6	141	42,6	22	203	Suspicion of proportion of biodiesel in Brazil
		[redacted]	7	1.112	6,3	3	30	
		[redacted]	5	2.437	2,1	1	10	
		[redacted]	5	789	6,3	3	30	
		[redacted]	1	?				
		Q-AL USA	1	---				
VW Tiguan	2.0l	[redacted]	1	18.752	0,1			
VW Jetta	2.0l	Testing in USA	1	---				
AudiA4/A5	unknown	[redacted]	3					
	unknown	[redacted]	1					
Grand total			108					
Field total			103					

	Qty.	Deliveries	Failure rate (per mill.)
[redacted]	29	2295	12,6
	27	478	56,5
	3	477	6,3
	16		
	15	62736	0,2

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Trial experience (CR findings; not relevant for approval)

6 x 500h with GDK 650μm positive*
*(1 failure after 490h due to piston seizure; cause: lack of C coating on piston)
2 x 100h with GDK 650μm positive

1 x 750h@2050 bar with kerosene (jet A1 kerosene F35) positive
1 x 500h@2050 bar with kerosene (jet A1 kerosene F35) positive

3 x WCF (water contaminated fuel) without AWP -> HP piston seizure
2 x WCF (water contaminated fuel) with CP4 with AWP -> drivetrain damage*

***Not in actual CR after pump breakdown Parts are highly corroded.**
Note: WCF results are not applicable to the series (1% water content)

<u>Note from Audi</u>:
The CP4 was tested positively and sufficiently in continuous running with EN590-compliant fuels.
Trials with "poorer fuel qualities of all kinds" were carried out in a much too narrow scope. In addition, these trials are largely not approval-relevant. The <u>CP4 is not sufficiently robust</u>, even with regard to filling and venting in customer service, engine test and on the vehicle assembly line.

From: Non-responsive content removed [redacted]
To:
CC:
Date: 7/28/2010, 2:03:16 PM
Subject: Re: First start times in [redacted]
Attachments: WG_ Erststartzeiten aller CR aus [redacted] .msg

Hello [redacted]

Regarding your statement:
[redacted] from [redacted] tried a while ago, unsuccessfully, to get these start times from FAT
[redacted]
They certainly have the data.
The contact person back then was [redacted]

@ Mr [redacted]
Did you respond to the proposal as to how to proceed?

>____
>Von: Non-responsive content removed [redacted]
>Sent: Friday, March 26, 2010, 10:58 AM
>To: Non-responsive content removed [redacted]
>Cc:
>Subject: Re: First start times in [redacted]
>
>Hello Mr. [redacted],
>
>Thank you for taking care of things so quickly.
> Section Confidential
>The average first start time of 21 sec. is very critical. This could also include vehicles that have to start even longer. In this case, preliminary damage to the high-pressure fuel pumps cannot be ruled out.
>Reasoning: If the venting is insufficient, there is nearly no fuel present in the pumps. If rotation takes place with starter rotational speeds in this case, there is a danger that the rollers in the pumps will not turn and suffer damage.
> Section Confidential
>The start times in [redacted] are 6 - 12 sec. (see attachment).
>
>Procedure for how to proceed:
>* Please determine the statistics for start times as described in the above attachment and send it to the above distribution list; also for vehicles in the field, if recorded. We have to know the max. first start times and rate which ones are most endangered.
>* Please conduct a process analysis soon and compare with [redacted] I suspect that the

vehicles in [redacted] are not vented sufficiently before the first start and therefore have the high start times. We urgently have to match this with the other plants.

>

>Please provide information as to your plans for how to proceed.

>

>If you are not the person responsible, please forward appropriately.

>

>

>Best regards

>

[redacted]

>

[redacted]

>www.audi.com

>

>

>

>

>____

>Von: [redacted]

>Sent: Friday, March 26, 2010, 9:30 AM

[redacted]

>Subject: Re: First start times in [redacted]

>

Hello colleagues,

>

>Here is the requested information:

> Section Confidential

>First start time average: 21s

>

>Filling quantity :> 14 l

>

>

>Is this information sufficient? Is the data okay or are their problems? What are the times and filling quantity in [redacted]

>

>Sincerely yours / Mit freundlichen Grüßen
>
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>
>AUDI AG
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>
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>Court of Registry/Registergericht: Amtsgericht Ingolstadt
>Commercial Register No./HRB Nr.: 1
>Chairman of the Supervisory Board/Vorsitzender des Aufsichtsrats: Martin Winterkorn>
>Vorstand/Board of Management: Rupert Stadler (Vorsitzender/Chairman), Ulf Berkenhagen, Michael Dick, Frank Dreves, Peter Schwarzenbauer, Axel Strotbek, Werner Widuckel
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>______________________________
>Von: Non-responsive content removed
>Sent: Wednesday, March 24, 2010, 6:46 PM
>To: Non-responsive content removed
>Cc:
>Subject: Re: First start times in [redacted]
>
>Hello [redacted]
>
>Could you please answer Non-responsive content removed questions?!
>
>Thanks!
>
Non-responsive content removed

>

>With best regards / Mit freundlichen Gruessen

>

[redacted]

>

>AUDI AG

[redacted]

>85045 Ingolstadt

>

[redacted]

>www.audi.com

>

>Sitz/Domicile: Ingolstadt

>Court of Registry/Registergericht: Amtsgericht Ingolstadt

>Commercial Register No./HRB Nr.: 1

>Chairman of the Supervisory Board/Vorsitzender des Aufsichtsrats: Martin Winterkorn

>Vorstand/Board of Management: Rupert Stadler (Vorsitzender/Chairman), Ulf Berkenhagen, Michael Dick, Frank Dreves, Peter Schwarzenbauer, Axel Strotbek, Werner Widuckel

>

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>Wichtiger Hinweis: Die vorgenannten Angaben werden jeder E-Mail automatisch hinzugefügt und lassen keine Rückschlüsse auf den Rechtscharakter der E-Mail zu.

>

>

>____

>Von: [redacted]

>Sent: Wednesday, March 24, 2010, 11:21 AM

>To: [redacted]

>Cc: [redacted]

>Subject: First start times in [redacted]

>

>

>Hello Mr. [redacted]

>

>Mr. [redacted] gave me a tip that you might be able to help me with questions involving production [redacted]

>

>We have V6 TDIs from [redacted] production that have damage to the high-pressure fuel pumps, some after only very short running times (minimum 235 km).

>

>It is possible that the pumps suffered preliminary damage during commissioning of the vehicles if the fuel system is not vented sufficiently during the first start. This is evident in the long first start times.

>

>Specific questions:

>* What are the first start times for the V6 TDIs?

>* Which fuel quantities are filled for the V6 TDIs at the plant?

>
>
>
>Best regards
>
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>
>Sitz/Domicile: Ingolstadt
>Court of Registry/Registergericht: Amtsgericht Ingolstadt
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>

>

EA11003EN-00116[0]

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B8 engine initial start times - Diesel

Initial start times, January 15, 2009

HPP type	Veh. class	VIN	Engine type	Vehicle type/data version	Start time [s]	Inspection date	Inspector	Prefilling	Location
CP4.1	B8	03-5-4151	R4 TDI, 2.0L-EU5	03L 906 022 KA 4235	9	15.01.2009	Non-responsive content removed [redacted]	> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4157	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	11	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4164	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	11	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4160	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	12	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4167	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	12	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4155	R4 TDI, 2.0L-EU5	03L 906 022 MG 4224	12	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4158	R4 TDI, 2.0L-EU5	03L 906 022 MR 4230	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4162	R4 TDI, 2.0L-EU5	03L 906 022 MP 4233	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4171	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4178	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4227	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4174	R4 TDI, 2.0L-EU5	03L 906 022 MG 4224	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	03-5-4176	R4 TDI, 2.0L-EU5	03L 906 022 MG 4224	14	15.01.2009		> 85 sec	A14-OG-IBN-Band
CP4.2	B8	03-5-4153	V6 TDI, 2.7L-EU5	8K1 907 401 B 0003	9	15.01.2009		>135 sec	A14-OG-IBN-Band
CP4.2	B8 convertit	48-3-4002	V6 TDI, 3.0L-EU5	8R0 907 401 C 0001	11	15.01.2009		>135 sec	A14-OG-IBN-Band
CP4.2	B8 convertit	50-2-4002	V6 TDI, 3.0L-EU5	8R0 907 401 C 0001	11	15.01.2009		>135 sec	A14-OG-IBN-Band
CP4.2	B8 convertit	50-2-4004	V6 TDI, 3.0L-EU5	8K0 907 401 C 0001	12	15.01.2009		>135 sec	A14-OG-IBN-Band
CP4.2	B8 convertit	50-5-4003	V6 TDI, 3.0L-EU5	8R0 907 401 C 0001	12	15.01.2009		>135 sec	A14-OG-IBN-Band

Initial start times, 2/6/2009

HPP type	Veh. class	VIN	Engine type	Vehicle type/data version	Start time [s]	Inspection date		Prefilling	Location
CP4.1	B8	07-1-4254	R4 TDI, 2.0L-EU5	03L 906 022 MG 4375	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4257	R4 TDI, 2.0L-EU5	03L 906 022 MG 4375	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4258	R4 TDI, 2.0L-EU5	03L 906 022 MK 4379	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4261	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	9	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4262	R4 TDI, 2.0L-EU5	03L 906 022 NG 4295	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4264	R4 TDI, 2.0L-EU5	03L 906 022 MK 4379	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4266	R4 TDI, 2.0L-EU5	03L 906 022 MK 4379	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4180	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4269	R4 TDI, 2.0L-EU5	03L 906 022 MR 4381	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4270	R4 TDI, 2.0L-EU5	03L 906 022 MK 4379	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4276	R4 TDI, 2.0L-EU5	03L 906 022 MK 4379	6	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4278	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4279	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4281	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4282	R4 TDI, 2.0L-EU5	03L 906 022 MJ 4378	7	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.1	B8	07-1-4285	R4 TDI, 2.0L-EU5	03L 906 022 MM 4377	8	06.02.2009		> 85 sec	A14-OG-IBN-Band
CP4.2	B8	07-1-4284	V6 TDI, 2.7L-EU5	8K1 907 401 B 0003	8	06.02.2009		>135 sec	A14-OG-IBN-Band
CP4.2	B8 convertible		V6 TDI, 3.0L-EU5						

C6PA engine initial start times - Diesel

Initial start times, January 15, 2009

HPP type	Veh. class	Veh. name	Engine type	Vehicle type/data version	Start time [s]	Inspection date	Inspector	Prefilling	Location
CP4.1	C6	03-5-2342	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	7	15.01.2009	Non-responsive content removed	> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2326	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	7	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2323	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	8	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2297	R4 TDI, 2.0L-EU5	03L 906 022 FL 3810	9	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2321	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	9	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2348	R4 TDI, 2.0L-EU5	03L 906 022 FG 3811	9	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2306	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	10	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2312	R4 TDI, 2.0L-EU5	03L 906 022 FG 3811	10	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2317	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	10	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2325	R4 TDI, 2.0L-EU5	03L 906 022 FG 3811	10	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2352	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	10	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2339	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	11	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2330	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	11	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2360	R4 TDI, 2.0L-EU5	03L 906 022 FL 3810	11	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2300	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	12	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	03-5-2206	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	12	15.01.2009		> 120 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2305	V6 TDI, 2.7L-EU5	4F7 910 401 004	7	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2318	V6 TDI, 2.7L-EU5	4F7 910 401 004	7	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6 Allroad	03-5-2295	V6 TDI, 2.7L-EU5	4F7 910 401 F 006	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2335	V6 TDI, 2.7L-EU5	4F7 910 401 004	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6 Allroad	03-5-2398	V6 TDI, 2.7L-EU5	4F7 910 401 F 006	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2302	V6 TDI, 2.7L-EU5	4F7 910 401 F 006	10	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2316	V6 TDI, 2.7L-EU5	4F7 910 401 004	11	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2327	V6 TDI, 2.7L-EU5	4F7 910 401 004	11	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2279	V6 TDI, 2.7L-EU5	4F7 910 401 004	11	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6 Allroad	03-5-2286	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	7	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2291	V6 TDI, 3.0L-EU5	4F9 910 401 Q 005	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2367	V6 TDI, 3.0L-EU5	4F2 910 115 K 002	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2099	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	8	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2338	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	9	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2329	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	10	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2336	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	10	15.01.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	03-5-2319	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	11	15.01.2009		> 240 sec	A14-OG-IBN-Band

Initial start times, 2/6/2009

EA11003EN-00116[2]

C6PA engine initial start times - Diesel

HPP type	Veh. class	Veh. name	Engine type	Vehicle type/data version	Start time [s	Inspection date	Inspector	Prefilling	Location
CP4.1	C6	07-2-2253	R4 TDI, 2.0L-EU5	03L 906 022 FL 3810	6	06.02.2009	[redacted] Non-responsive content removed	> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2256	R4 TDI, 2.0L-EU5	03L 906 022 FG 4397	8	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2258	R4 TDI, 2.0L-EU5	03L 906 022 FL 3810	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2260	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	8	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2267	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	7	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2274	R4 TDI, 2.0L-EU5	03L 906 022 FG 4397	9	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2275	R4 TDI, 2.0L-EU5	03L 906 022 FG 4397	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2279	R4 TDI, 2.0L-EU5	03L 906 022 FG 4397	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2282	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2186	R4 TDI, 2.0L-EU5	03L 906 022 FL 3810	7	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2288	R4 TDI, 2.0L-EU5	03L 906 022 SB 3787	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2301	R4 TDI, 2.0L-EU5	03L 906 022 FG 4397	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.1	C6	07-2-2304	R4 TDI, 2.0L-EU5	03L 906 022 FH 3812	6	06.02.2009		> 120 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2249	V6 TDI, 2.7L-EU5	4F7 910 401 004	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2101	V6 TDI, 2.7L-EU5	4F7 910 401 004	10	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2252	V6 TDI, 2.7L-EU5	4F7 910 401 F 006	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2259	V6 TDI, 2.7L-EU5	4F7 910 401 F 006	11	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2265	V6 TDI, 2.7L-EU5	4F7 910 401 004	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2269	V6 TDI, 2.7L-EU5	4F7 910 401 004	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2271	V6 TDI, 2.7L-EU5	4F7 910 401 004	6	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2277	V6 TDI, 2.7L-EU5	4F7 910 401 004	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2295	V6 TDI, 2.7L-EU5	4F7 910 401 004	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2284	V6 TDI, 2.7L-EU5	4F7 910 401 004	9	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2303	V6 TDI, 2.7L-EU5	4F7 910 401 004	9	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2291	V6 TDI, 2.7L-EU5	4F7 910 401 004	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2286	V6 TDI, 2.7L-EU5	4F7 910 401 004	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2247	V6 TDI, 3.0L-EU5	4F9 910 401 Q 005	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2257	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	06-4-2174	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	10	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2263	V6 TDI, 3.0L-EU5	4F9 910 401 Q 005	10	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2264	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	10	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2268	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2276	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	7	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2278	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	9	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2281	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2283	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	8	06.02.2009		> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2287	V6 TDI, 3.0L-EU5	4F9 910 401 Q 005	10	06.02.2009		> 240 sec	A14-OG-IBN-Band

C6PA engine initial start times - Diesel

CP4.2	C6	07-2-2141	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	9	06.02.2009	Non-responsive content removed	> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2300	V6 TDI, 3.0L-EU5	4F9 910 401 F 006	6	06.02.2009	[redacted]	> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2289	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	6	06.02.2009	[redacted]	> 240 sec	A14-OG-IBN-Band
CP4.2	C6	07-2-2305	V6 TDI, 3.0L-EU5	4F9 910 401 E 007	11	06.02.2009	[redacted]	> 240 sec	A14-OG-IBN-Band

CP4.2 engine measurements, tappet movement about the vertical axis

Task:

- Measurements at the W19 CO2 engine: Tappet movement about the vertical axis

Test execution:

- CP4.2 2x4.85mm
- Test sequences:
  - Ramp 1,000 - 4,500 (5,000) rpm engine speed
  - Engine Start/Stop
  - MVEG Test
- Parameter:
  - Fuel:Diesel (measured density at approx. 30 °C: 828 kg/m³)
  - Kerosene (measured density at approx. 30°C: 781 kg/m³)
  - Runoff position of the pump in US, LS and in the flanks below 45°

Measuring equipment

- Data acquisition of analog data LTT 186/16
- CP4.2 equipped with instruments:
  - Tappet movement about vertical axis, axial path of camshaft,
  - Shear stress of tappet spring and acceleration at the pump housing
  - US pump
  - Engine speed

CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Sequence and number of measurements:

Fuel	Starts	Ramps 1000-4500 rpm	Warm-up 20 - 30 min	MVEG	Other
Diesel	11	6	2	1	Turning: clockwise / anticlockwise
Reassembly of cylinder heads for C-coated pistons					
Diesel	2	1	1		
Switching to kerosene (about 45 minutes engine run)					
Kerosene	7	3	1	1	
Switching to diesel (about 45 minutes engine run)					
Diesel	9		1		
Reassembly of right cylinder head for p__element measurement					
Diesel	10	2	1		Towing, rotation by hand

Engine running time with kerosene approximately 1.5 to 2 hours

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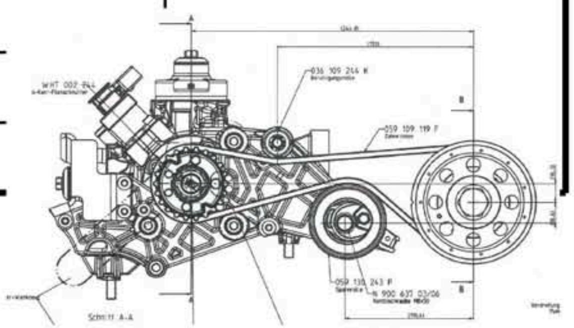
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Max. tappet movement about the vertical axis (peak to peak):

Fuel	Motor starts rotation angle [°] left cylinder	right cylinder	Ramps 1000-4500 rpm rotationangle [°] left cylinder	Right cylinder	Other
Diesel	1.5	0.4	1.0	0.4	
Reassembly of cylinder heads for C-coated pistons					
Diesel	7**	3**	2.4** (0.5)	2.6** (0.4)	** Before start-up
Switching to kerosene (about 45 minutes engine run)					
Kerosene	1.2 (6)	1	0.4	0.8	() for last measurement
Switching to diesel (about 45 minutes engine run)					
Diesel	6	1.5	0.4	0.5	
Reassembly of right cylinder head for p_Element measurement					
Diesel	6	1	0.4	0.5	



**After cylinder head assembly, without spring clearance before start-up () Values m m in brackets at 4500 rpm after start-up

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CP4.2 engine measurements, tappet movement about the vertical axis

Results:

- Turned tappet >1.5° found only in the start case
- During the last start with kerosene, turned tappet was 6° to the left cylinder
- After replacing oil with diesel, often 6° turned tappet during engine start
- No striking features during engine start-up under load at max. speed

Summary:

- Start case is more critical in terms of turned tappet than rpm ramp-up
- 6° turned tappet only at the 1st stroke of the pump to the left cylinder **w thout p_EL**
- For photo documentation of drivetrain parts of metering pump, see following slides

Further work:

- Evaluation of all measurements
- Evaluation of the measured spring shear stresses
- Evaluation of the measured acceleration signals

CP4 tests at the engine with diesel / kerosene

Fact

-> Photo documentation of CP4.2 drivetrain parts after tests for the Audi engine with diesel and kerosene

-> Turned tappet measurements carried out during start tests.

-> Significant winding on the roller tappet to the left (about 6°) measured

-> Results:

-> Light edge support on the cam in cam run-up

-> Alignment mark in LS

-> Skewing of the roller in the cam profile recognizable

-> 2 skid marks on the roller, left roller as well as 2 very fine skid marks on the running surface of the right roller

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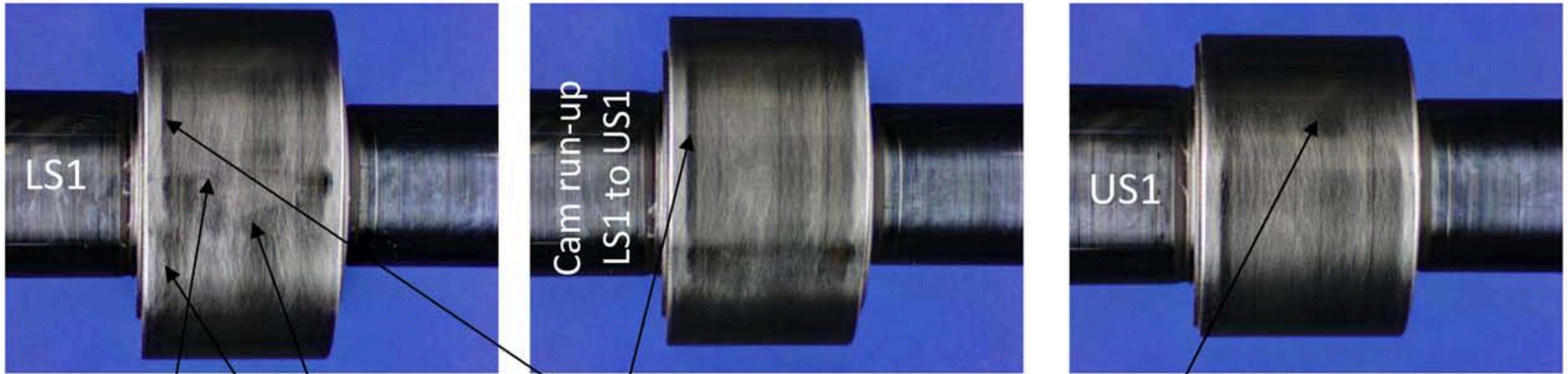
CP4 tests at the engine with diesel / kerosene

Camshaft images



Roller alignment mark in LS

Rounding the edge in cam run-up

Skewing of the roller in the cam run-down

Slight smoothening in the center of the cam **->** Indication of winding in US

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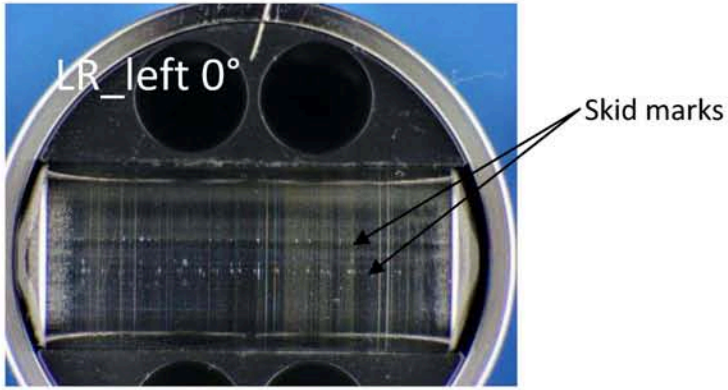
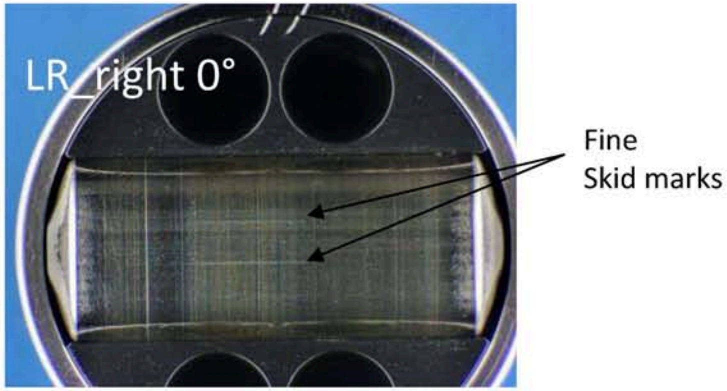
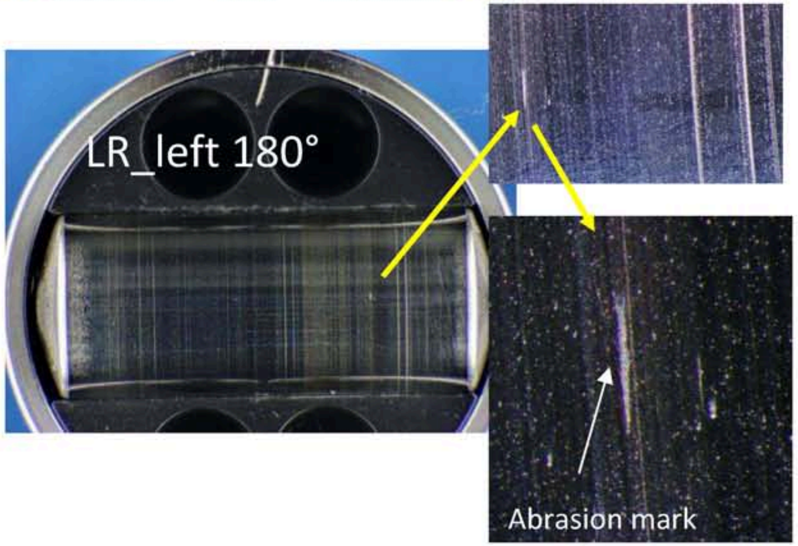
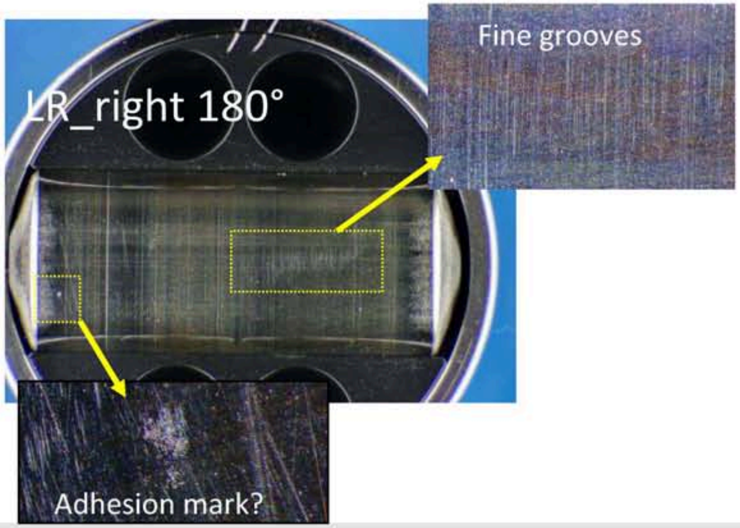
CP4 tests at the engine with diesel / kerosene

Roller images









CP4.2 engine measurements, tappet movement about the vertical axis

Detailing:	Fuel	Slide no.
• Engine start prior to rpm ramp-up	Diesel	9 , 10
• Engine start after rpm ramp-ups	Diesel	11 , 12
• Engine start	Kerosene	13 , 14
• Engine start	Diesel	15 - 17
• Engine start pump partly vented, vented with measurement p_El	Diesel	18 - 24
• rpm ramp-up after cylinder head assembly Without clearance ("assembly pre-stressing spring")	Diesel	25
• rpm ramp-up 1000-max. rpm var. load	Diesel	26 - 28
• rpm ramp-up 1000-max. rpm var. load	Kerosene	29 - 30

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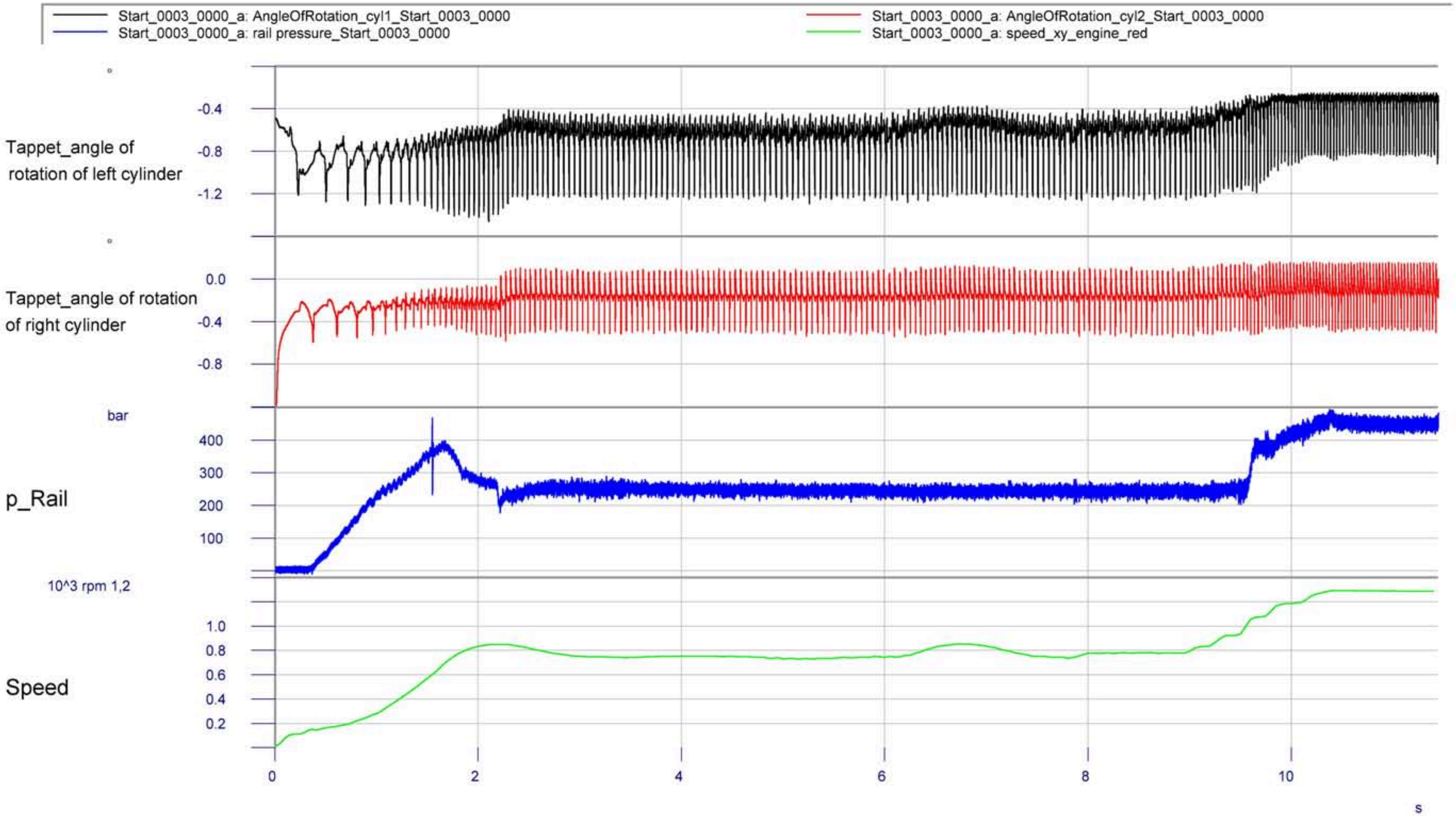
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Overview of start with diesel, before rpm ramp-up

Diesel



Diesel systems

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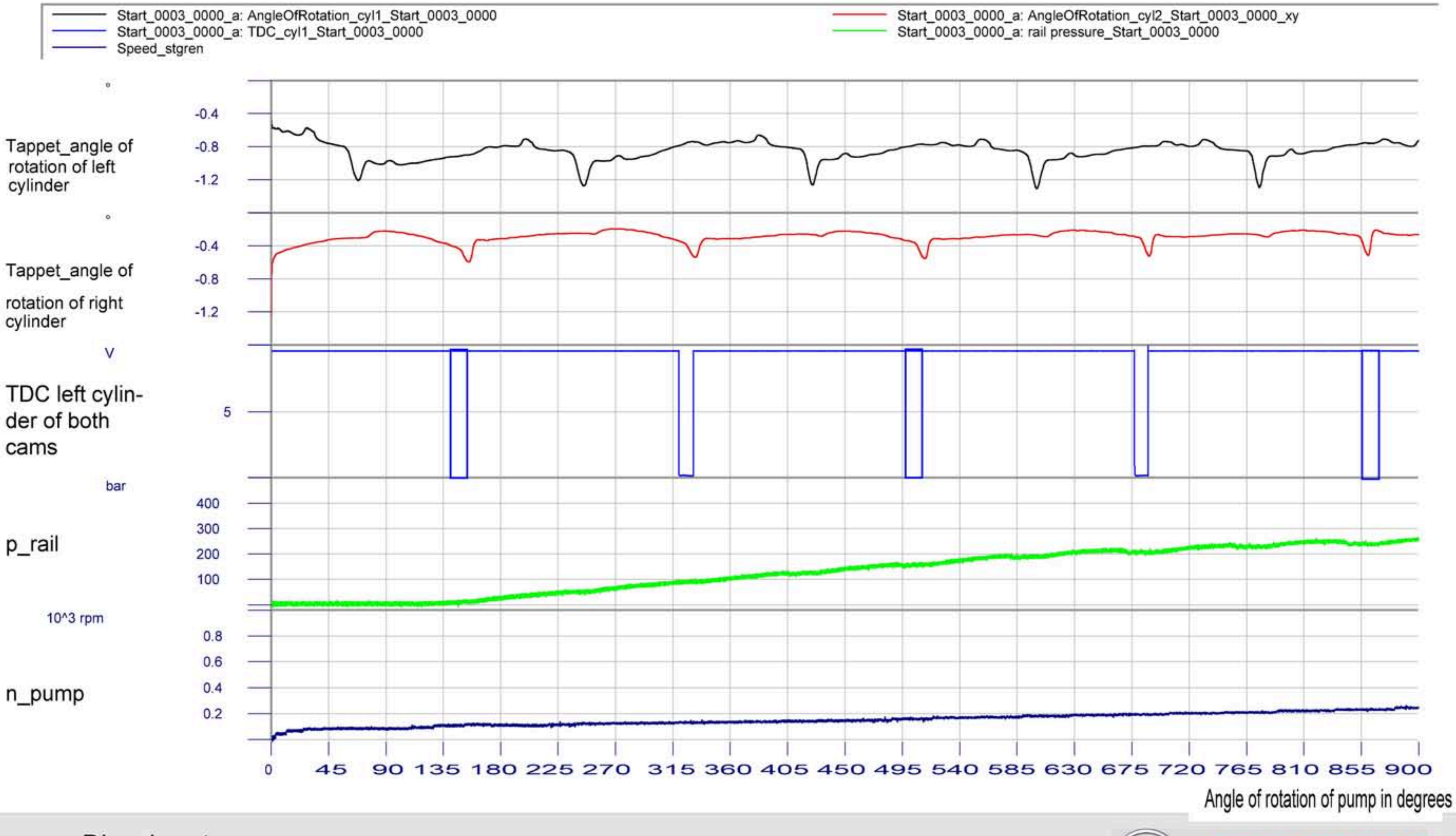
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start with diesel

Diesel



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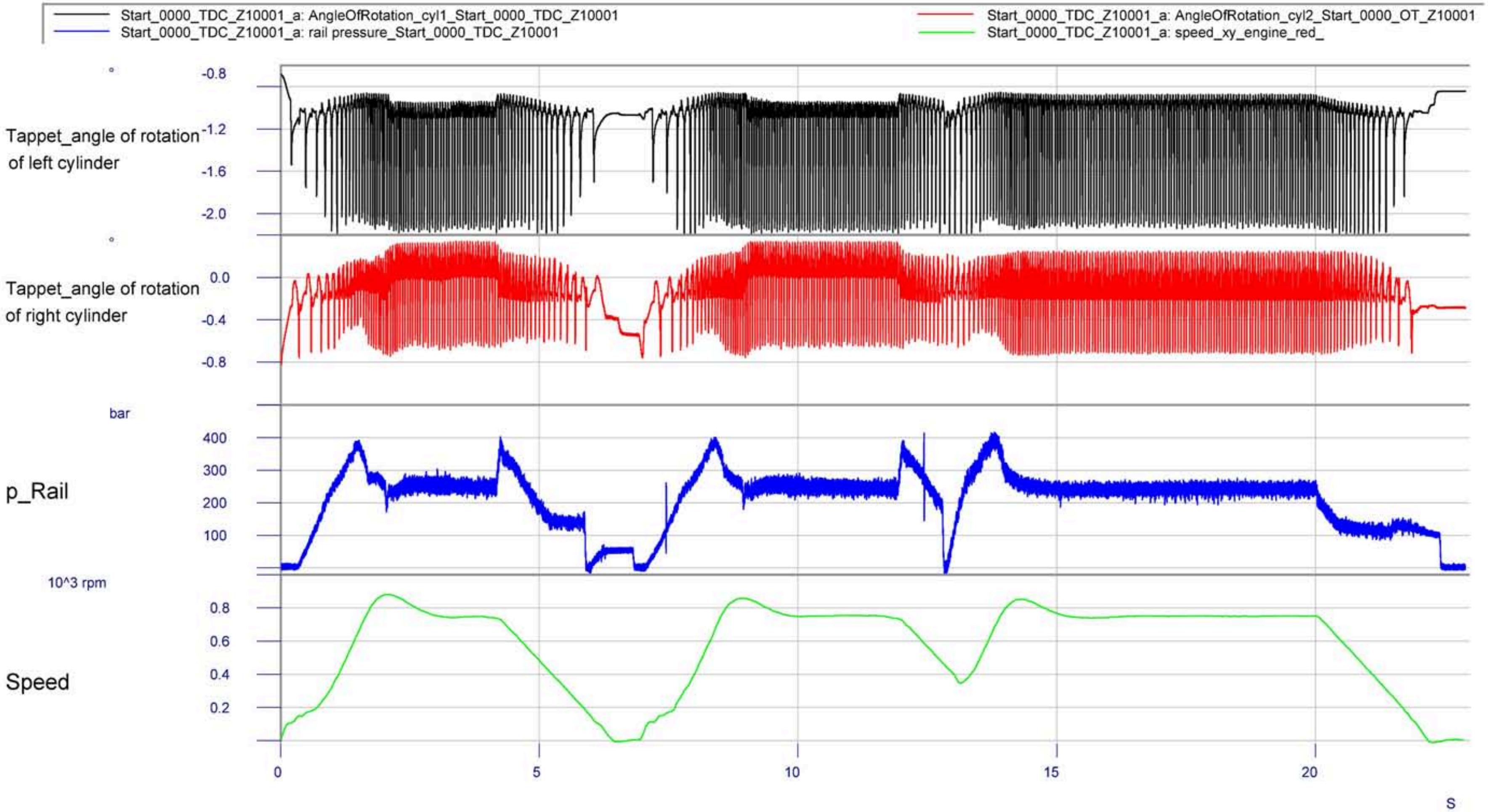
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Overview of start with diesel, after 6 rpm ramp-ups

Diesel



Diesel systems

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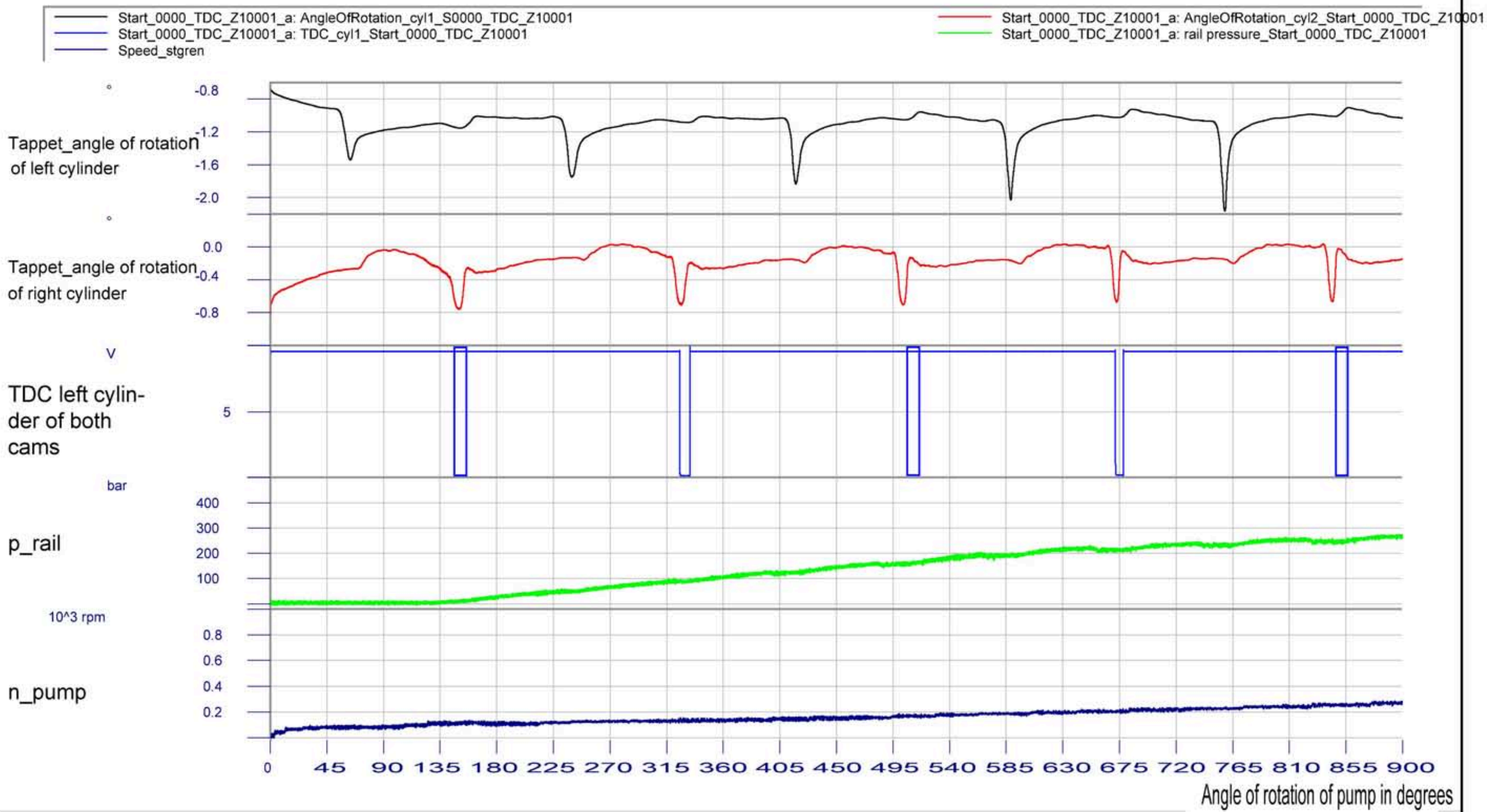
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start with diesel, after 6 rpm ramp-ups

Diesel



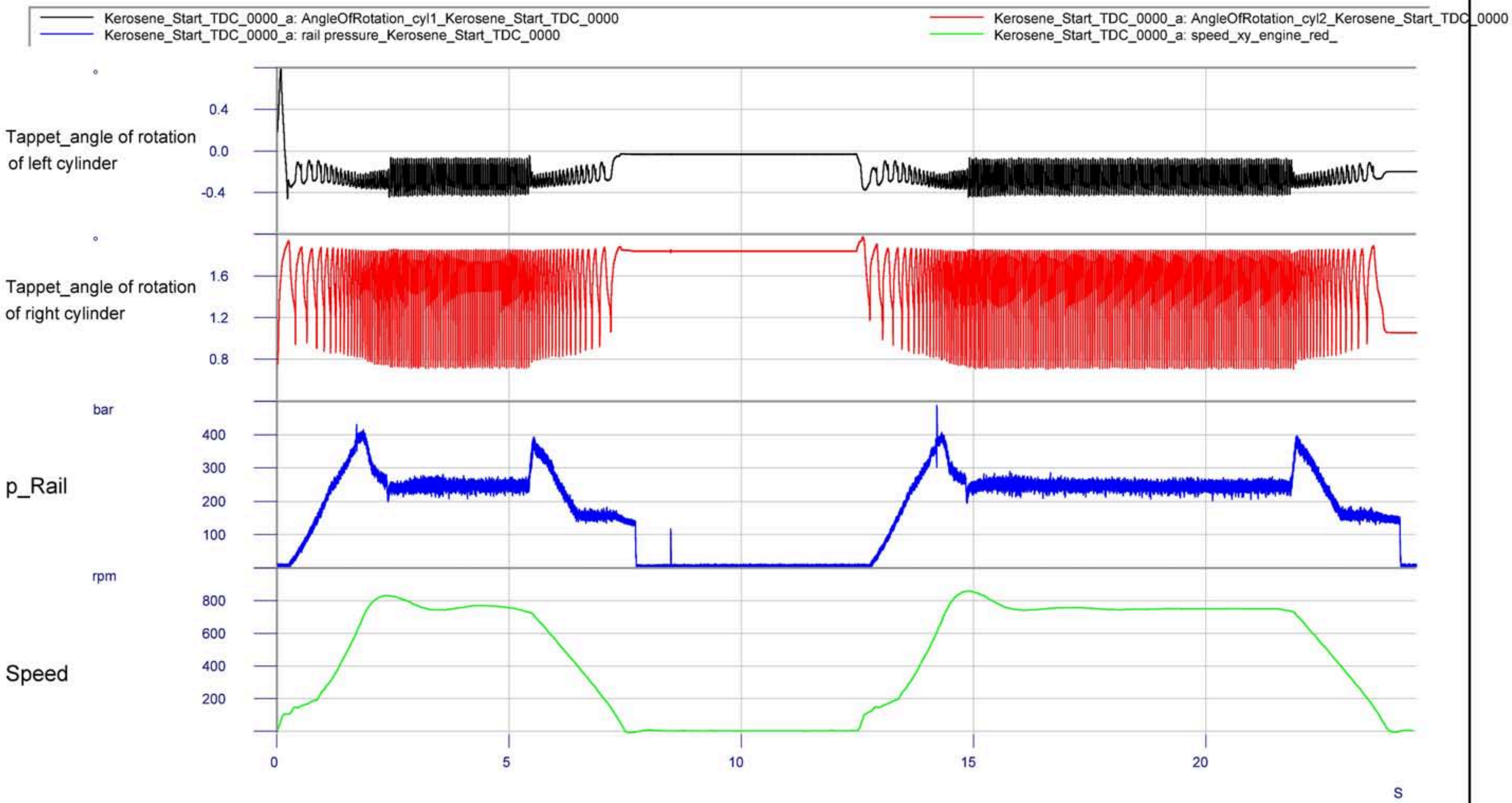
Diesel systems

BOSCH

CP4.2 engine measurements, tappet movement about the vertical axis

Tappet angle of rotation at engine start: Overview of start with kerosene

Kerosene



Diesel systems

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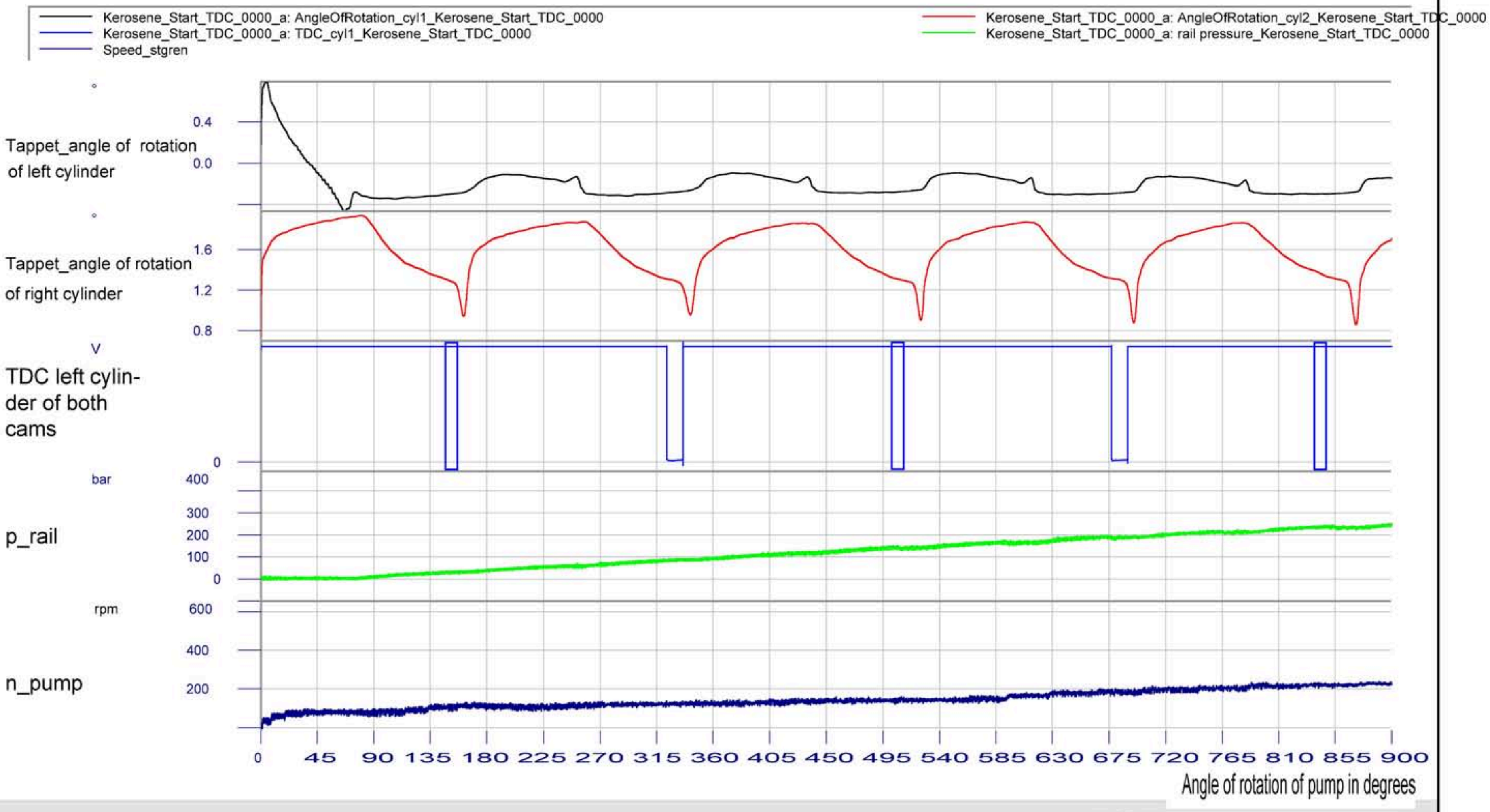
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start with kerosene

Kerosene



Diesel systems

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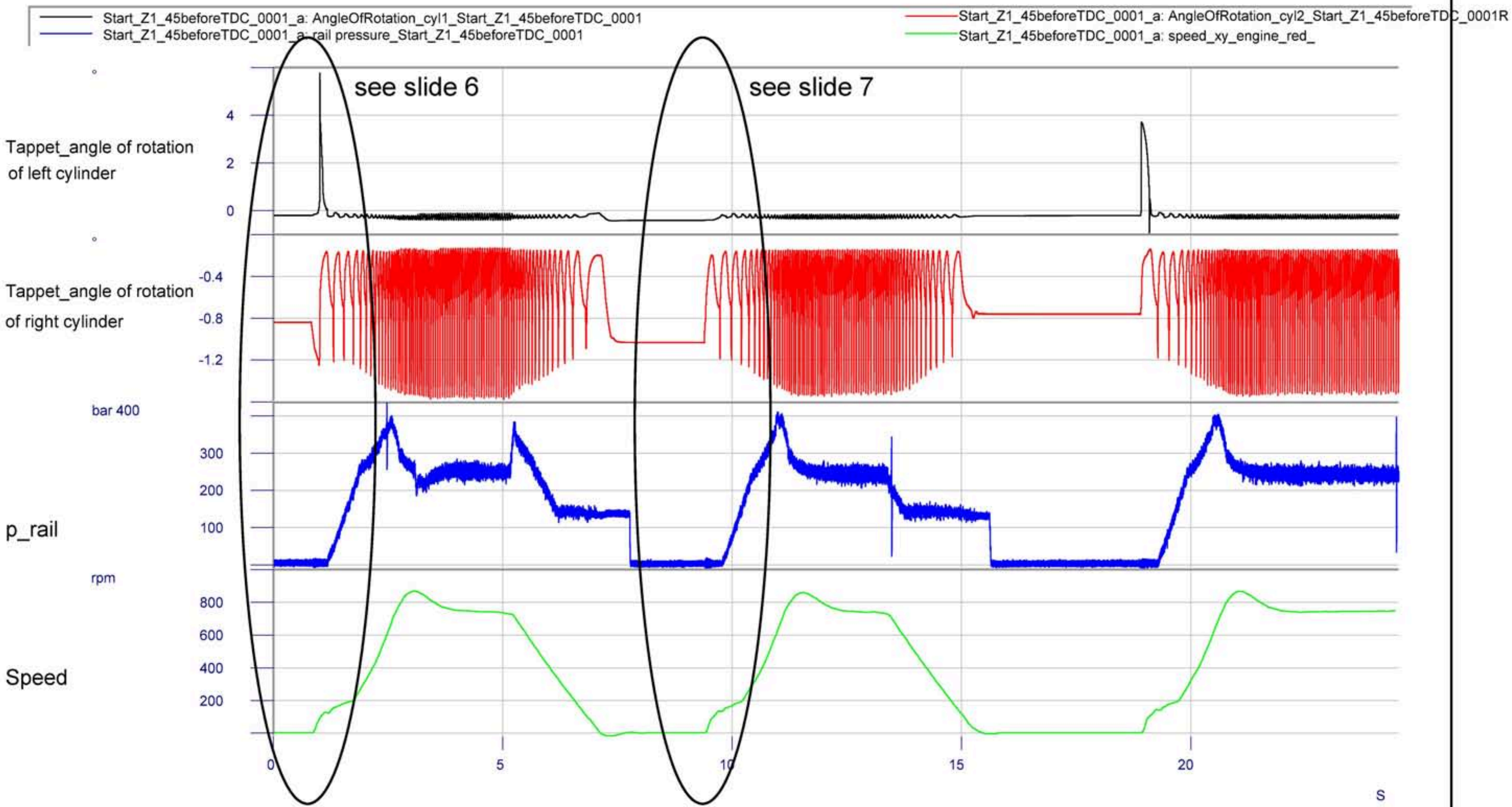
CP4.2 engine measurements, tappet movement about the vertical axis

Diesel

Tappet angle of rotation at engine start: Overview of start with diesel after kerosene test



Diesel systems

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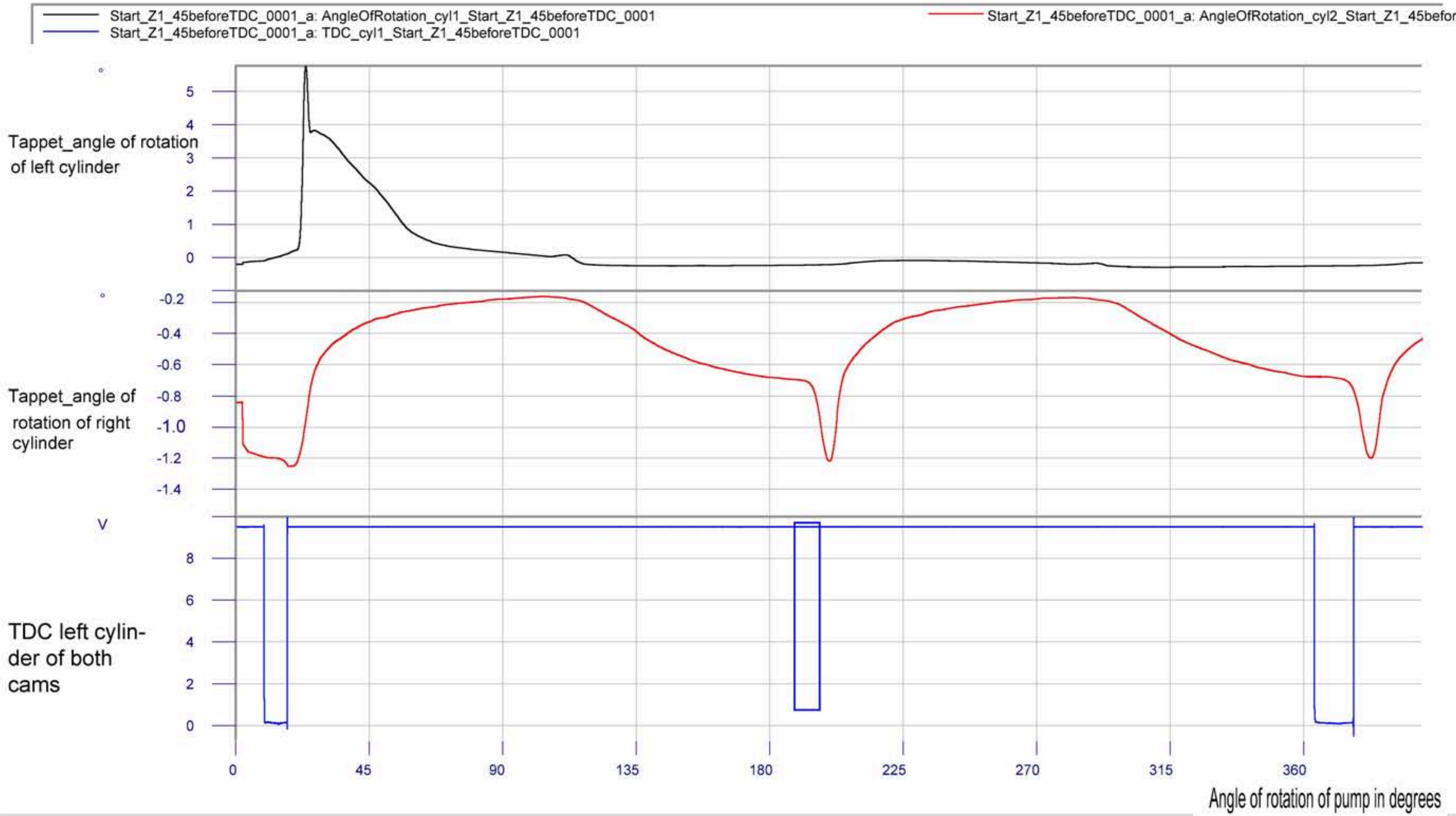
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Overview of start with diesel after kerosene test

Diesel



Diesel systems

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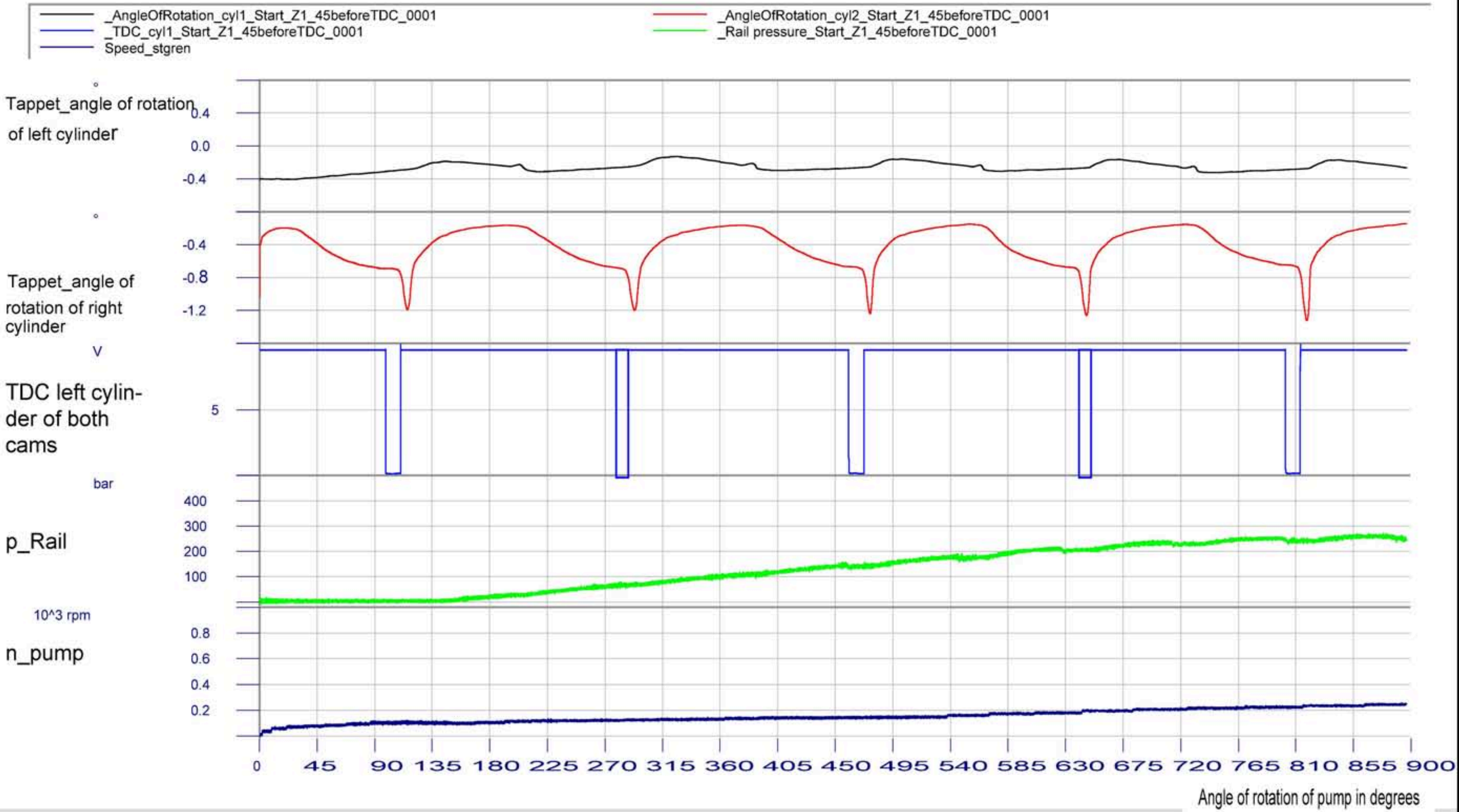
CP4.2 engine measurements, tappet movement about the vertical axis

CP4 Diesel

Tappet angle of rotation at engine start: Overview of start with diesel after kerosene test



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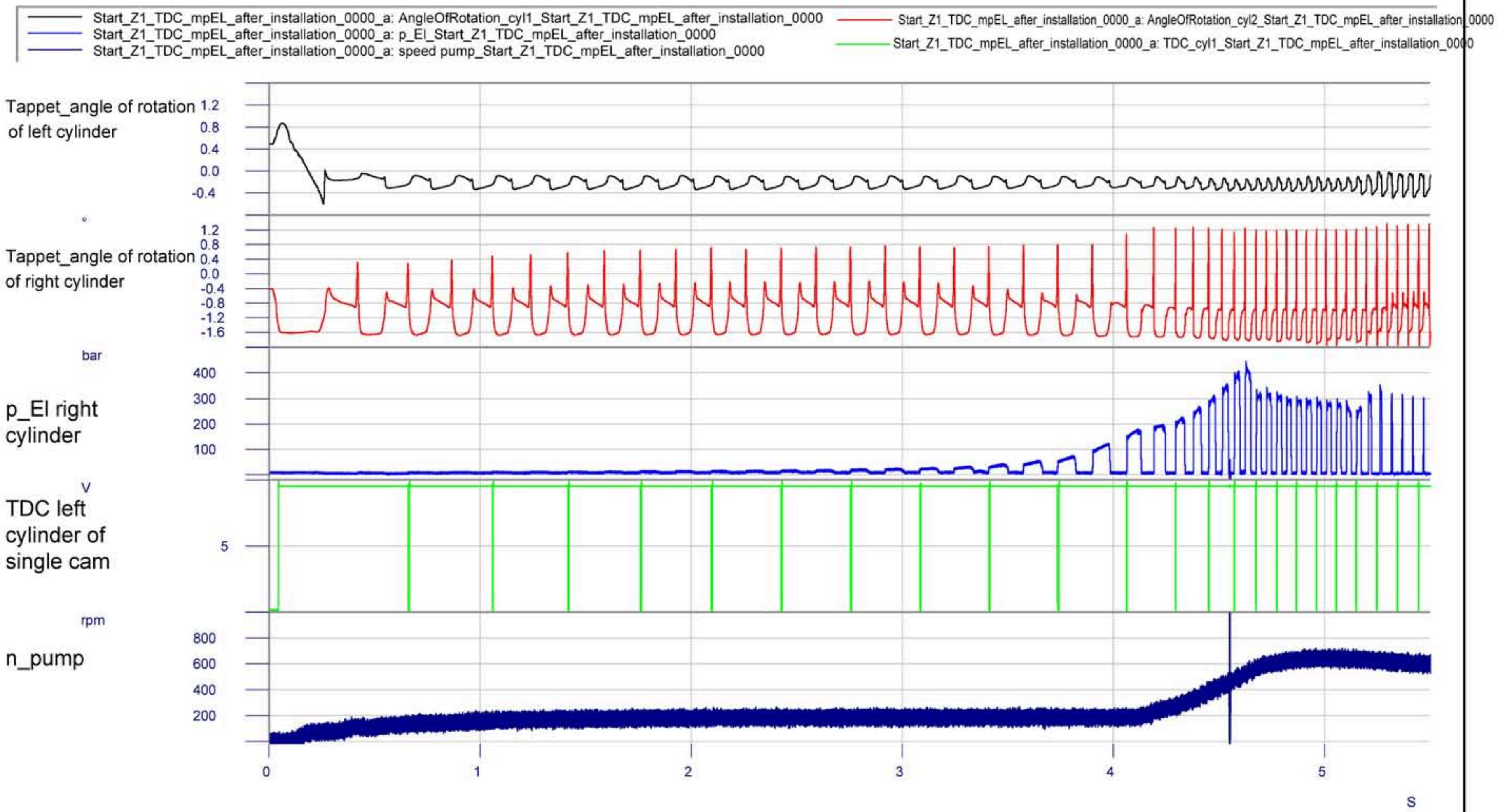
CP4.2 engine measurements, tappet movement about the vertical axis

CP4 Diesel

Tappet angle of rotation at engine start: Detailed start after assembly p_EL ZK on the right cylinder



Diesel systems

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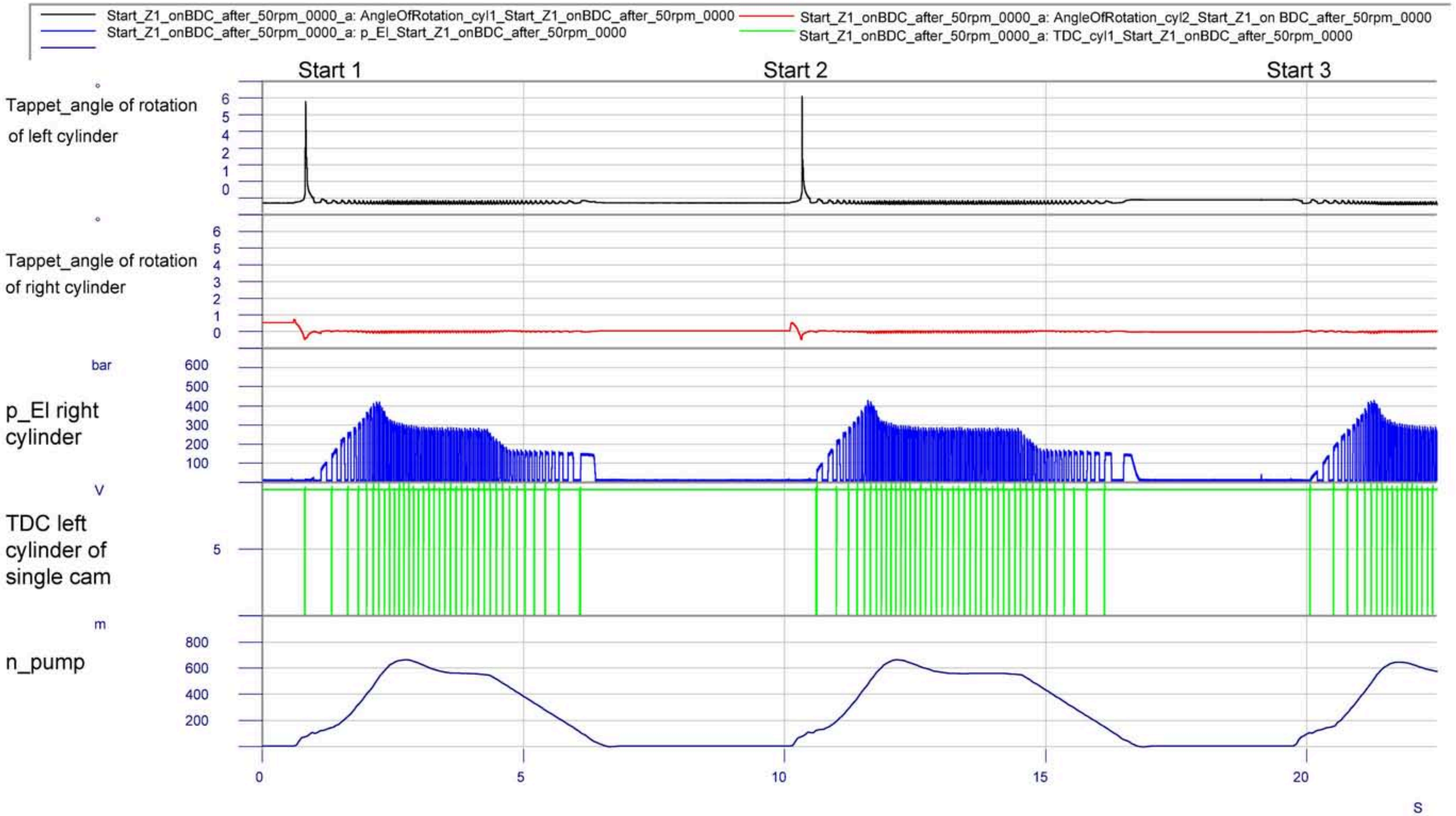
CP4.2 engine measurements, tappet movement about the vertical axis

Diesel

Tappet angle of rotation at engine start: 3 starts pump filled



Diesel systems

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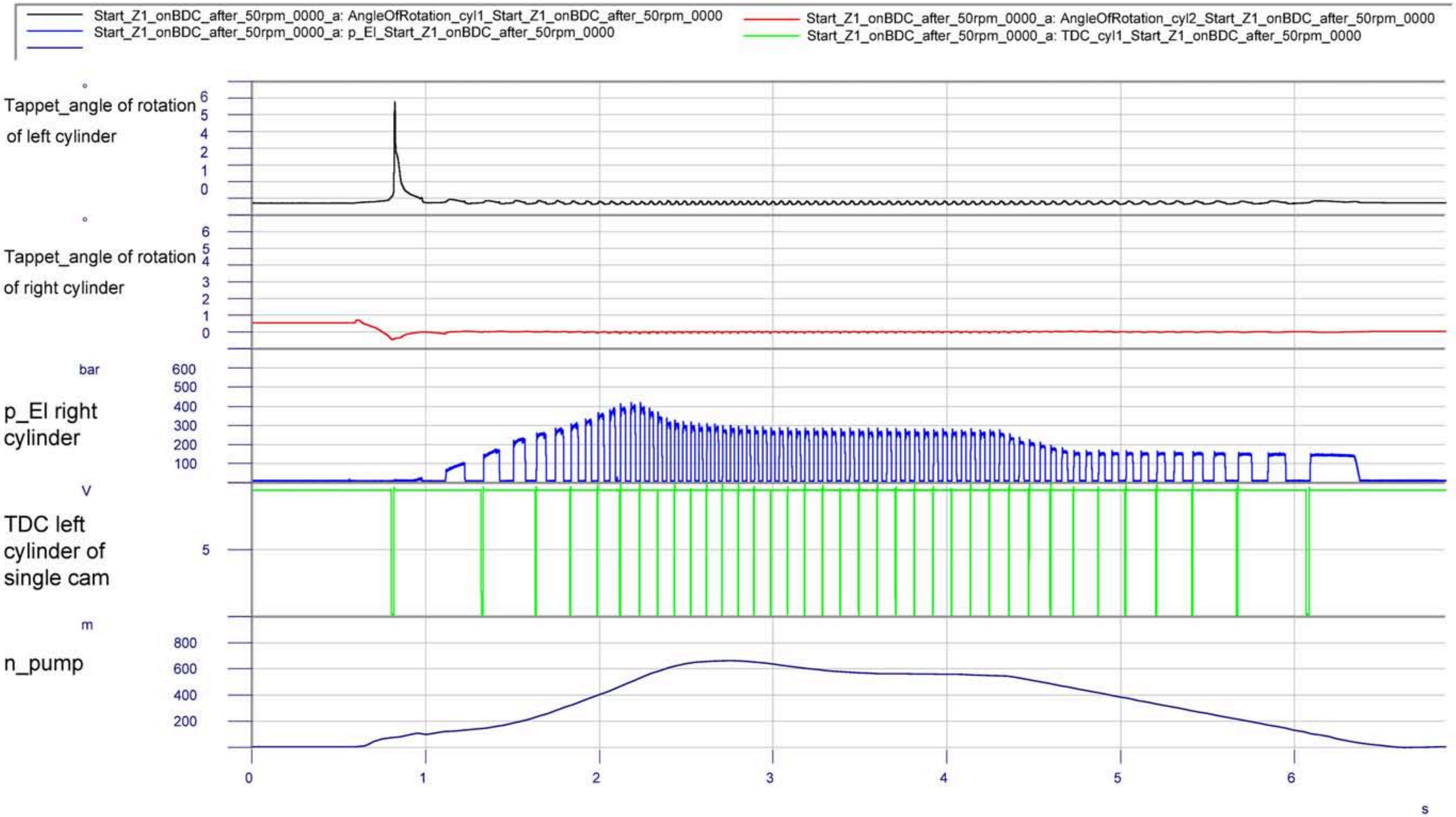
CP4.2 engine measurements, tappet movement about the vertical axis

Diesel

Tappet angle of rotation at engine start: Detailed start 1, pump filled



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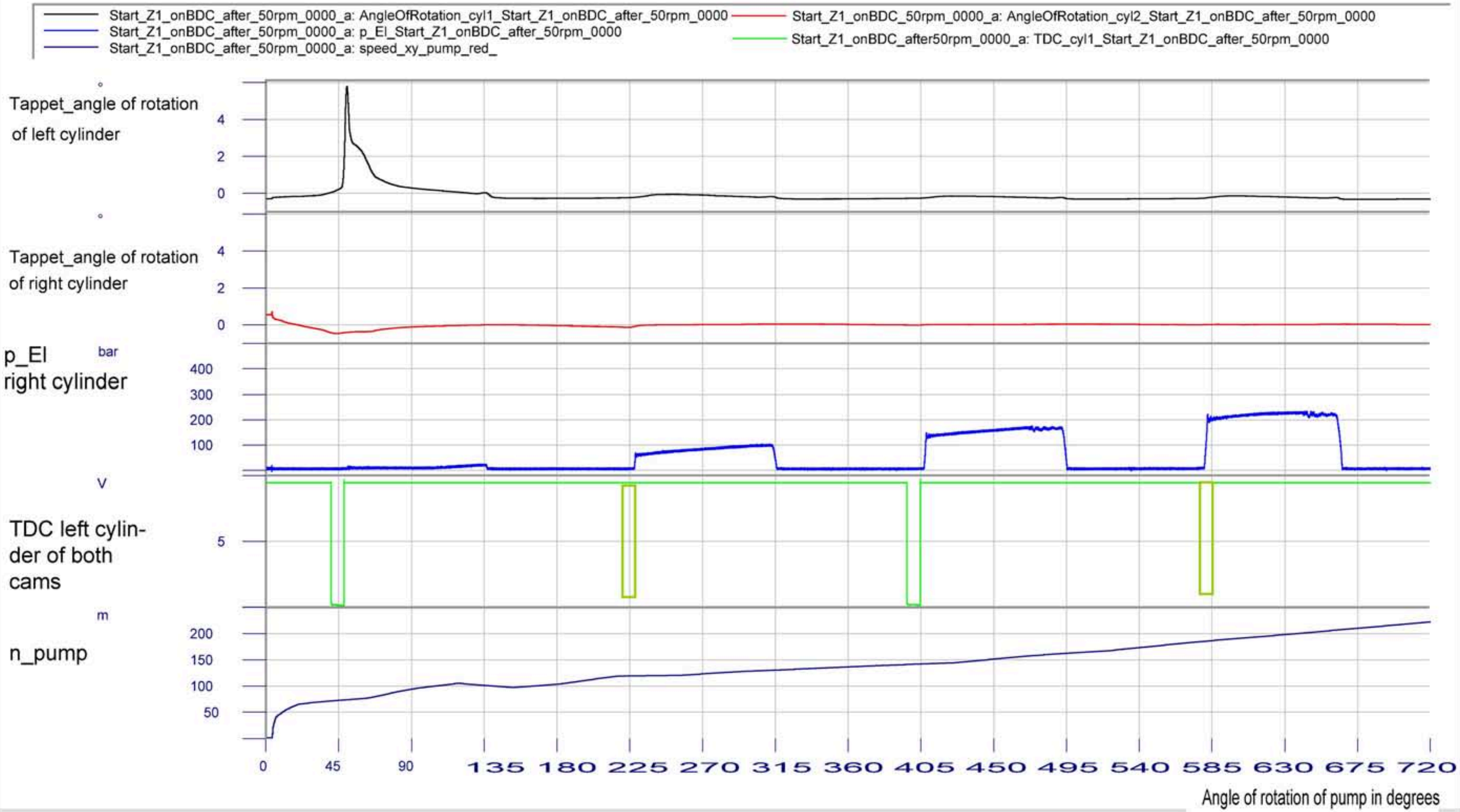
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start 1, pump filled, run-off to left LS Cylinder

Diesel



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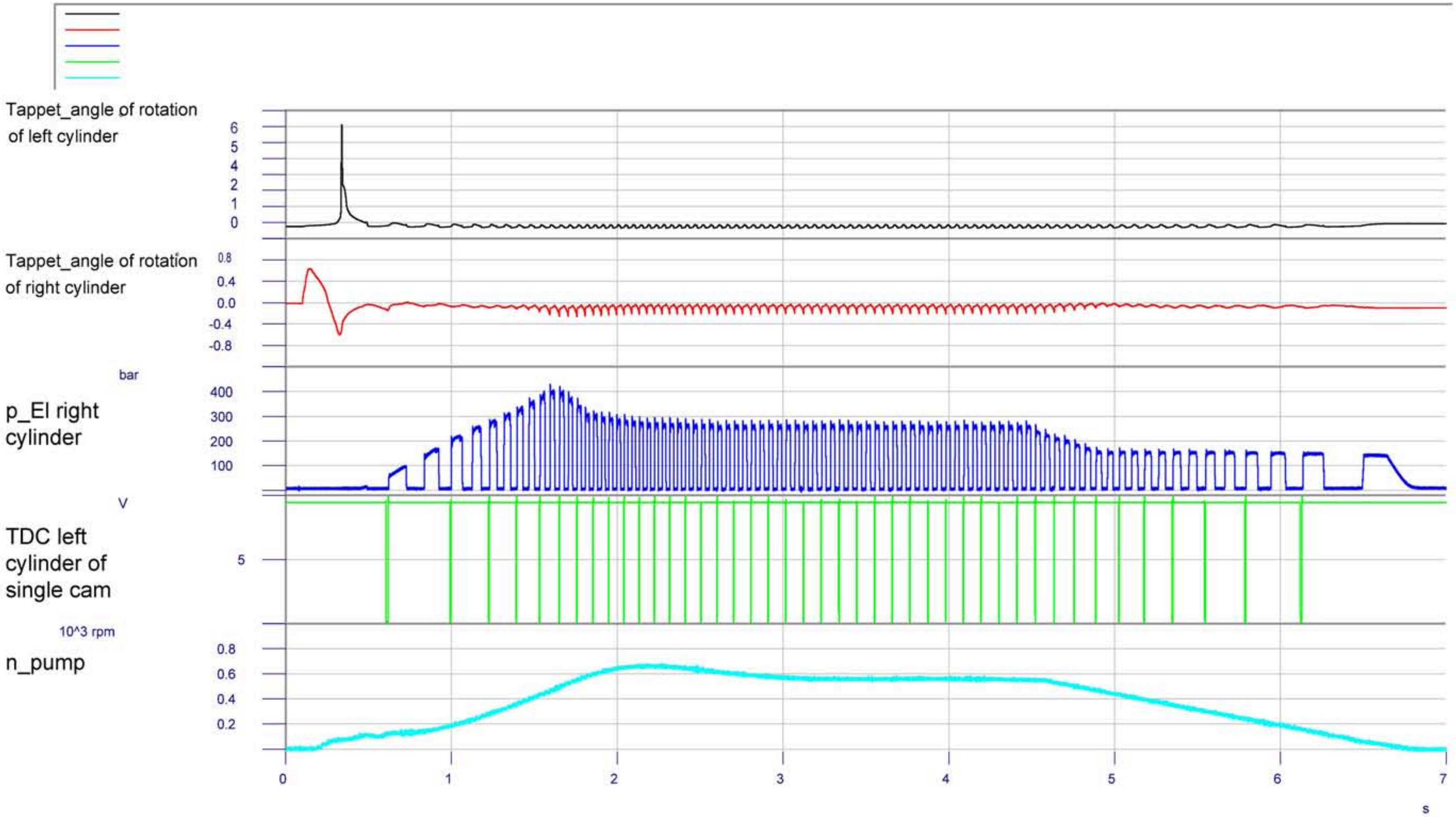
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Diesel

Tappet angle of rotation at engine start: Detailed start 2, pump filled



Diesel systems

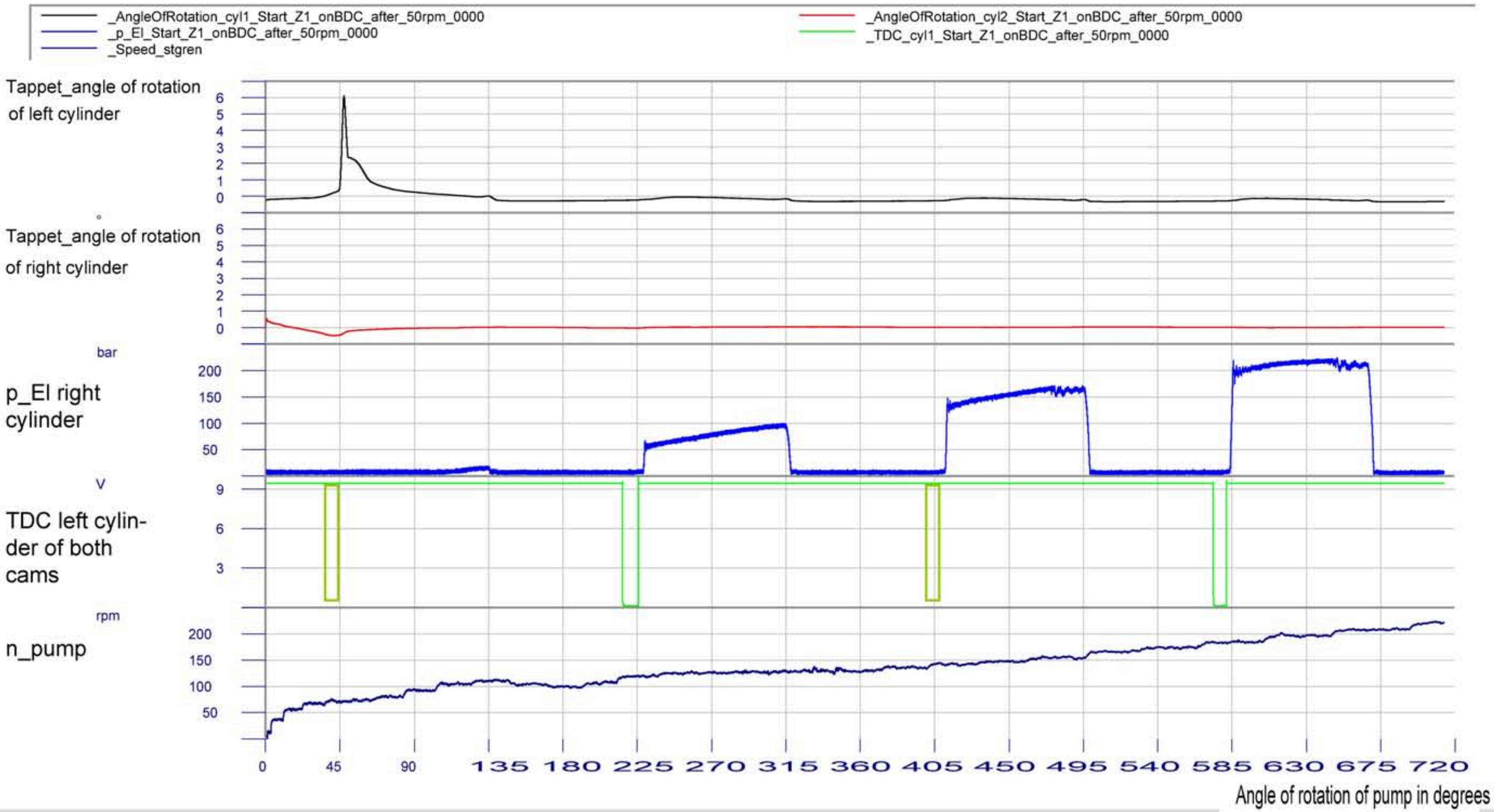
BOSCH

CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start 2, pump filled, run-off to left LS Cylinder

Diesel



Diesel systems

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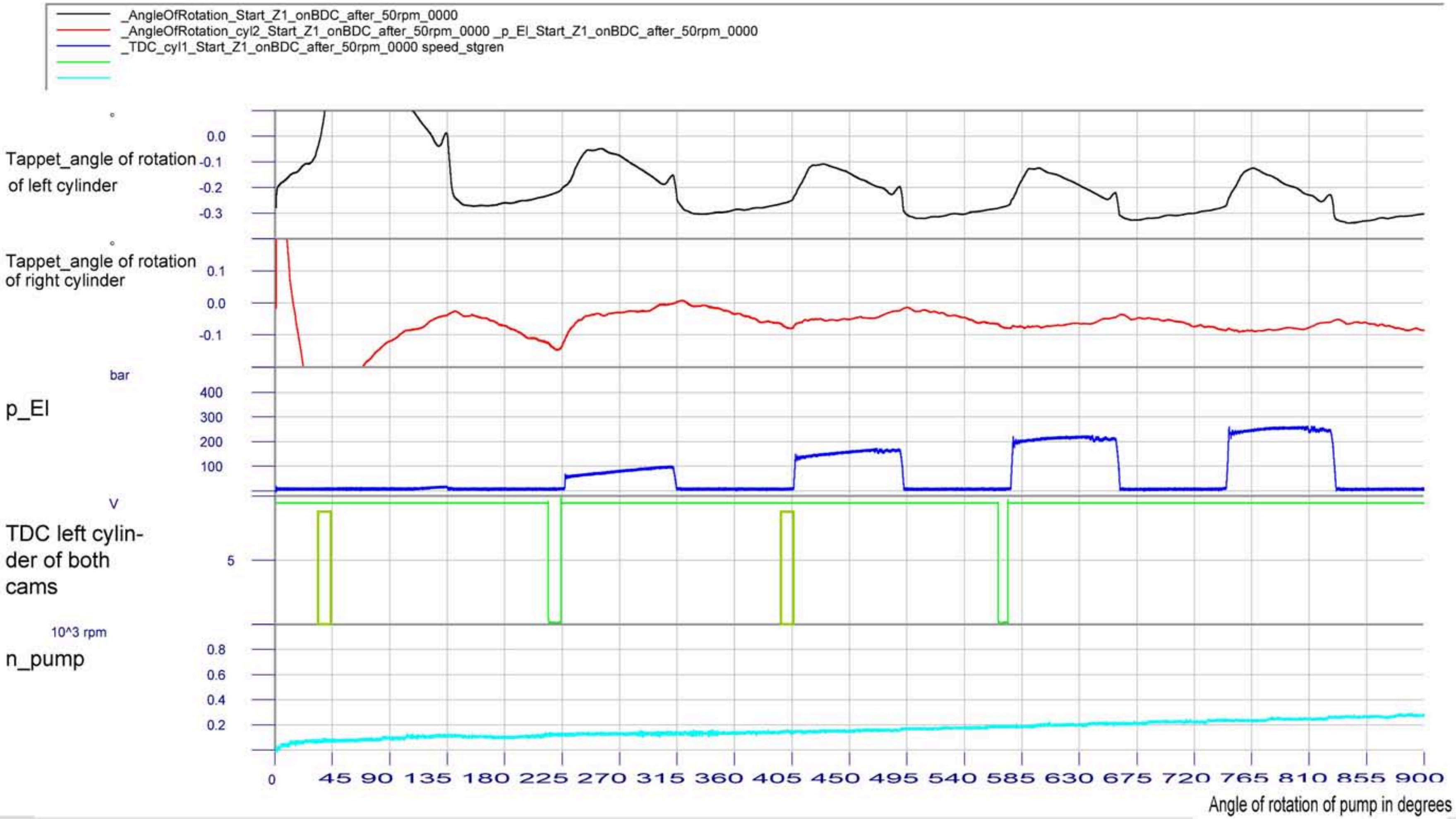
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Tappet angle of rotation at engine start: Detailed start 2, pump filled, run-off to left LS Cylinder

Diesel



Diesel systems

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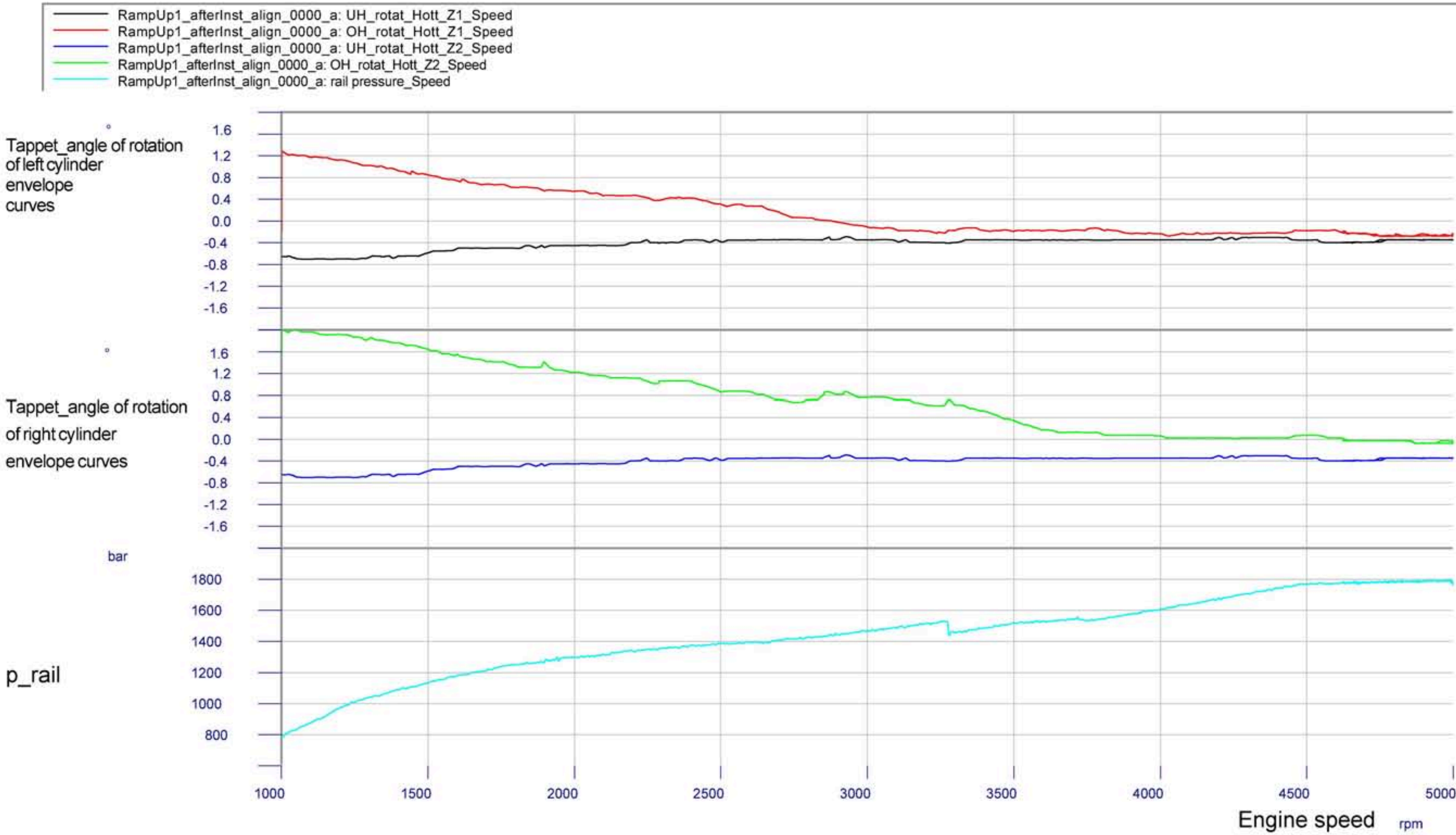
CP4.2 engine measurements, tappet movement about the vertical axis

Diesel

rpm ramp-up after cylinder head assembly without spring clearance



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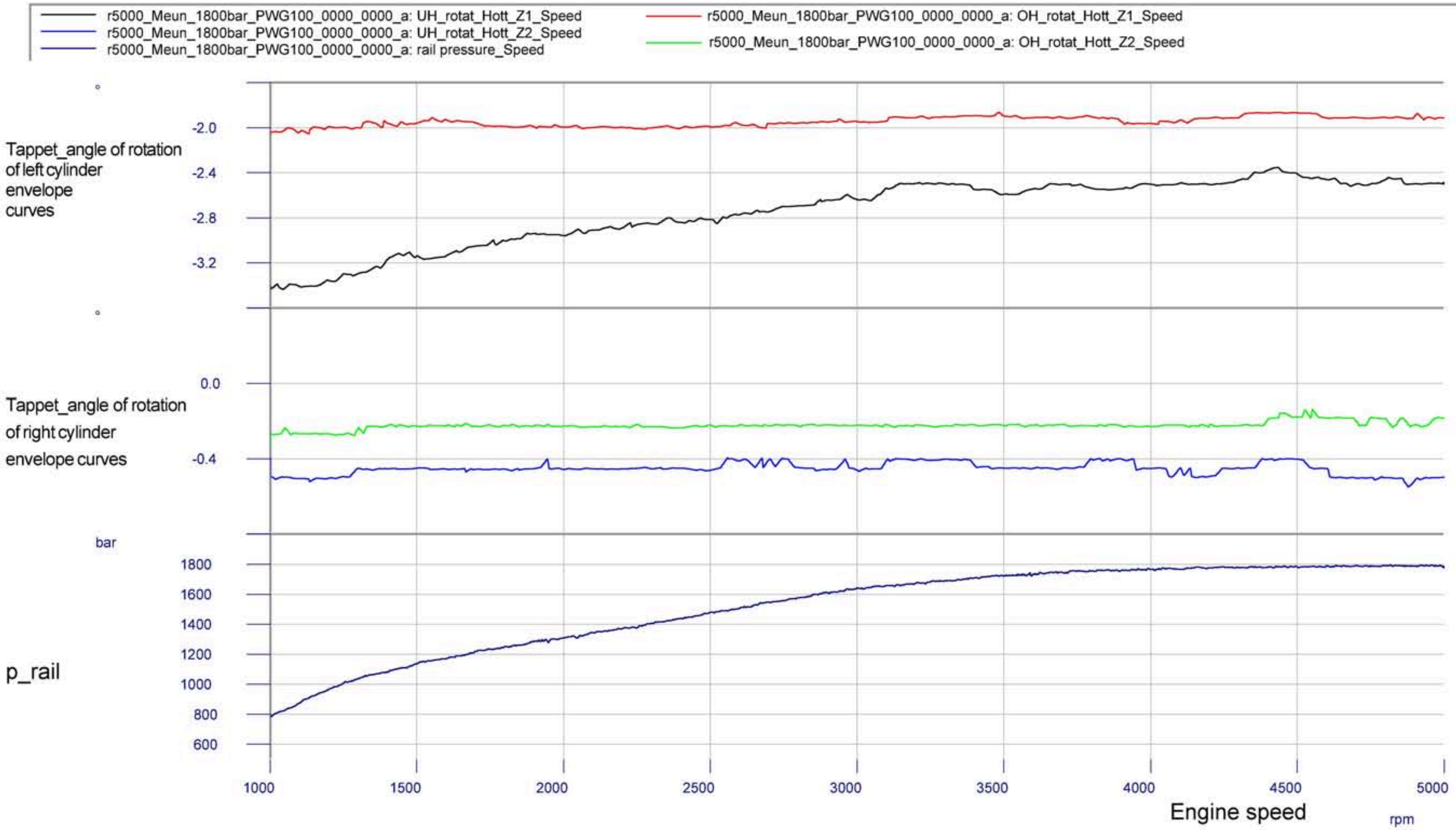
CP4.2 engine measurements, tappet movement about the vertical axis

CP4

Diesel

rpm ramp-up, 1000-5000 rpm engine



Diesel systems

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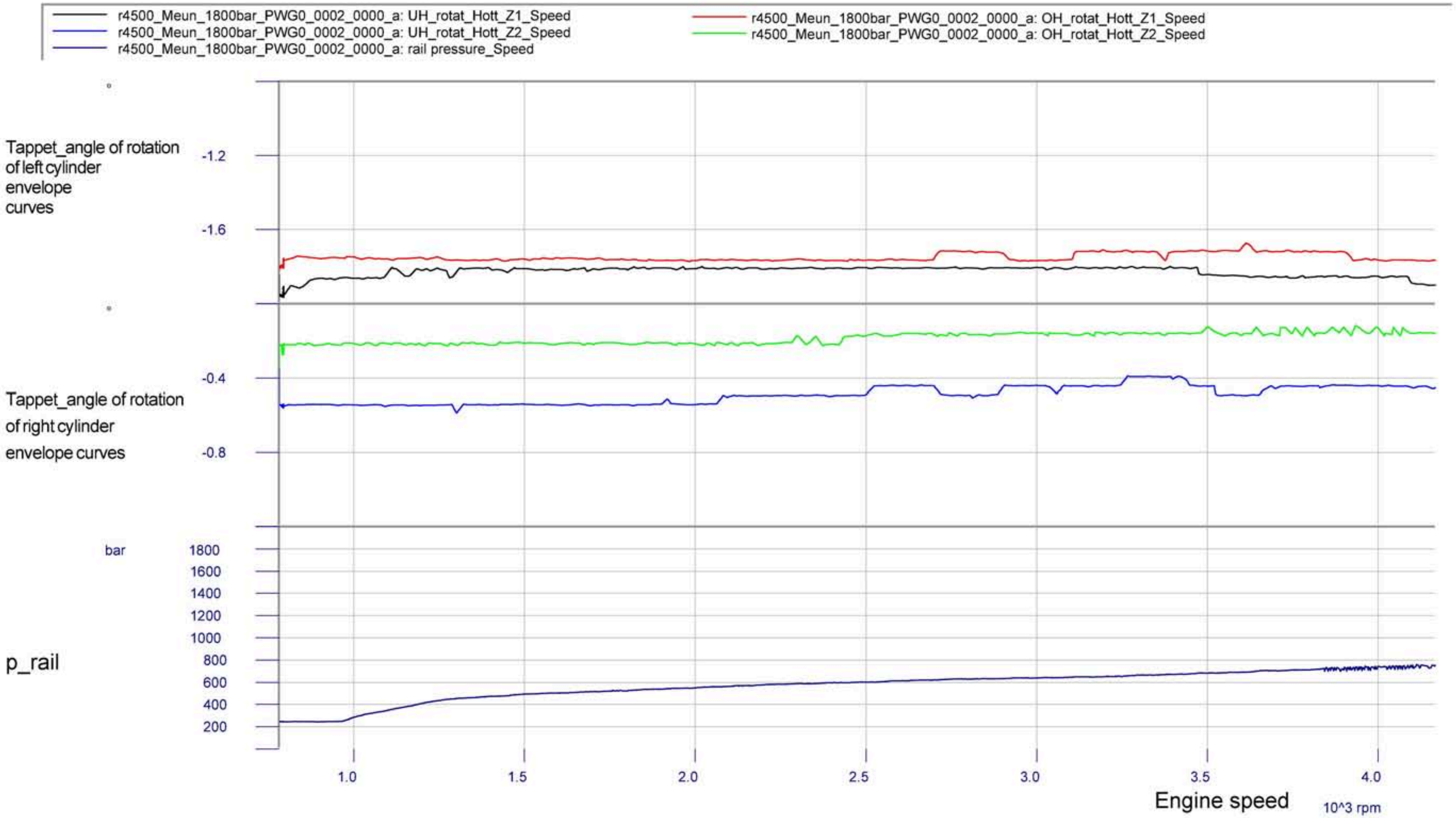
CP4.2 engine measurements, tappet movement about the vertical axis

Diesel

rpm ramp-up coasting, 1000-4300 rpm engine



Diesel systems

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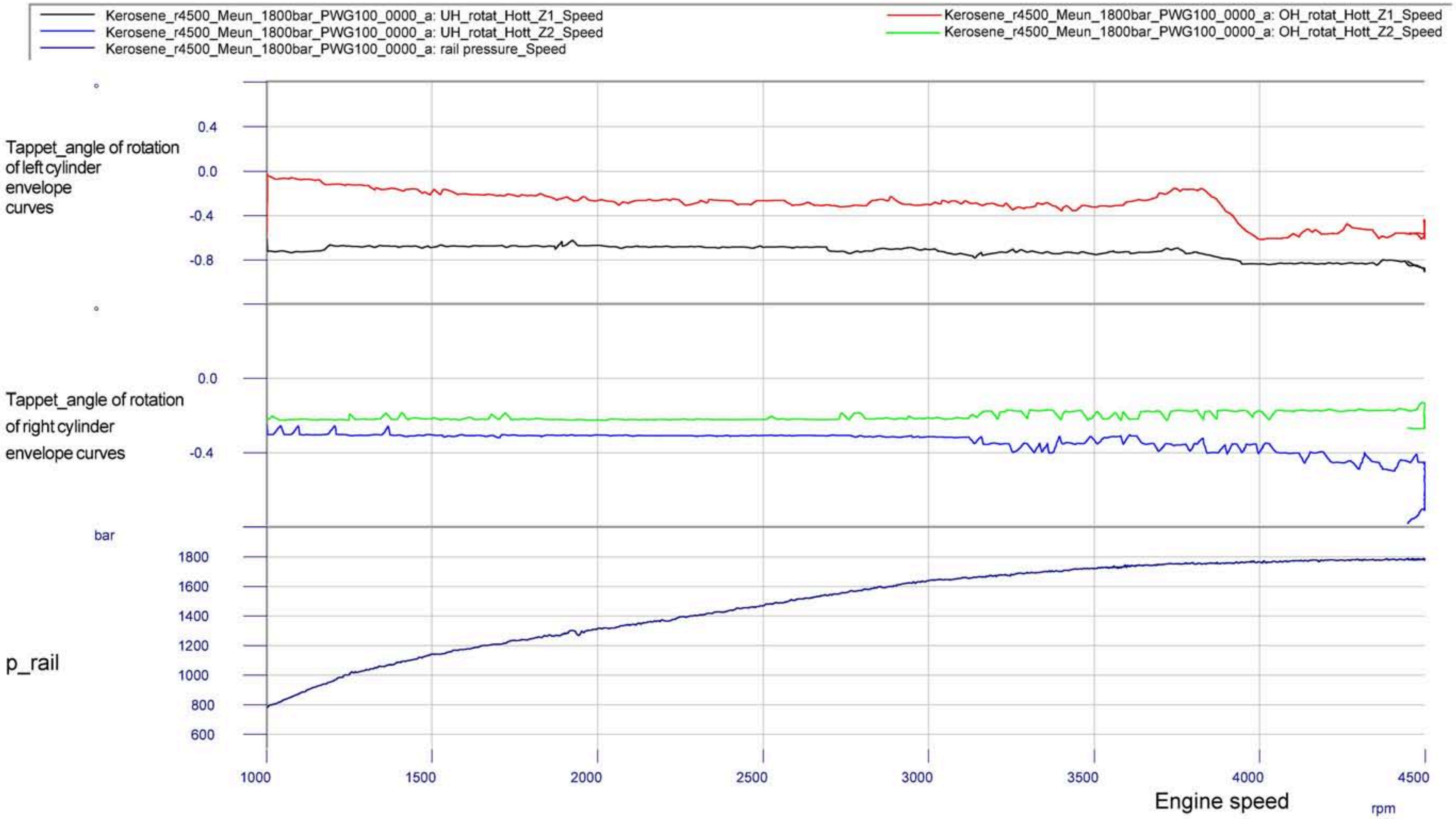
CP4.2 engine measurements, tappet movement about the vertical axis

rpm ramp-up full load, 1000-4500 rpm engine

Kerosene



Diesel systems

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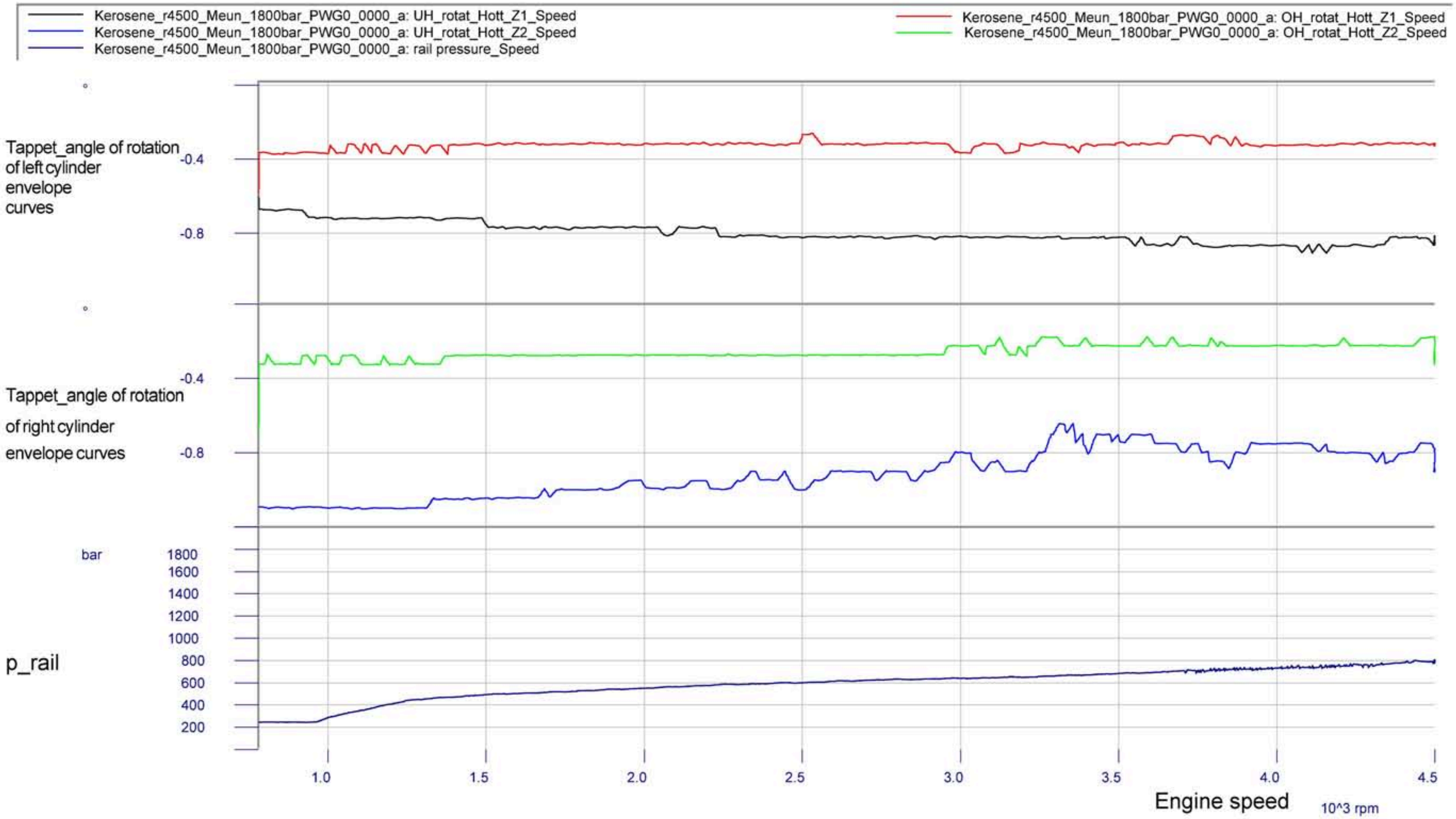
CP4.2 engine measurements, tappet movement about the vertical axis

rpm ramp-up coasting, 1000-4500 rpm engine

Kerosene



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VW-R4 (2.0l_low) EU5
– CRS3.2 –

Notes on initial commissioning of CRS in association with the cold test inspection

12/01/2005

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VW-R4_2.0l_low: Notes on initial commissioning

To note during assembly

→ Cleanliness requirements, particularly for supply lines to diesel fuel filter.

→ Installation and service notes.

→ Installation requirements (e.g. tightening torques), also see respective component TCDs and proposal drawings.

Initial filling of injection system

→ All TCD values must be followed!

→ Permissible filling fluid: Diesel fuel compliant DIN EN590, however HFRR ≤ 400µm

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VW-R4_2.0l_low: Notes on initial commissioning

Recommendation <u>before</u> venting, initial commissioning, and cold test:

→ Perform electrical check (e.g. CRI3.2: contacting, capacity measurement for low voltages, etc.
{Note: pay attention to line lengths and resistances of connectors})

Venting of CR system is performed for
- the low-pressure circuits through the CP4 return,
- the high-pressure part (CP4, rail) through suction or HP valve, through the PCVu in total return.

For cold test commissioning:
→ Activation does not take place through engine electronic control unit → test bench control is needed
(Activation of PCVu, MU; CRI3.2 should not inject)

VW-R4_2.0l_low: Notes on initial commissioning

Venting high-pressure fuel pump CP4 (without CP) with predelivery EFP

For CP4:

→ Dry running of the high-pressure fuel pump is not allowed!

→ Minimum filling/pre-pressure of 4.5bar_abs must <u>always</u> be ensured through predelivery EFP .

→ max. return pressure 1.8bar_abs **U*** (continuous running ≥1.8bar_abs can cause damage to the shaft seal).

→ With a rail pressure of 0bar, the max. drag speed is **U*** n_{CP}=300U/min.

→ Operation of pump only permitted within pressure limit curve CP4 (Tab.1, Diag. 1).

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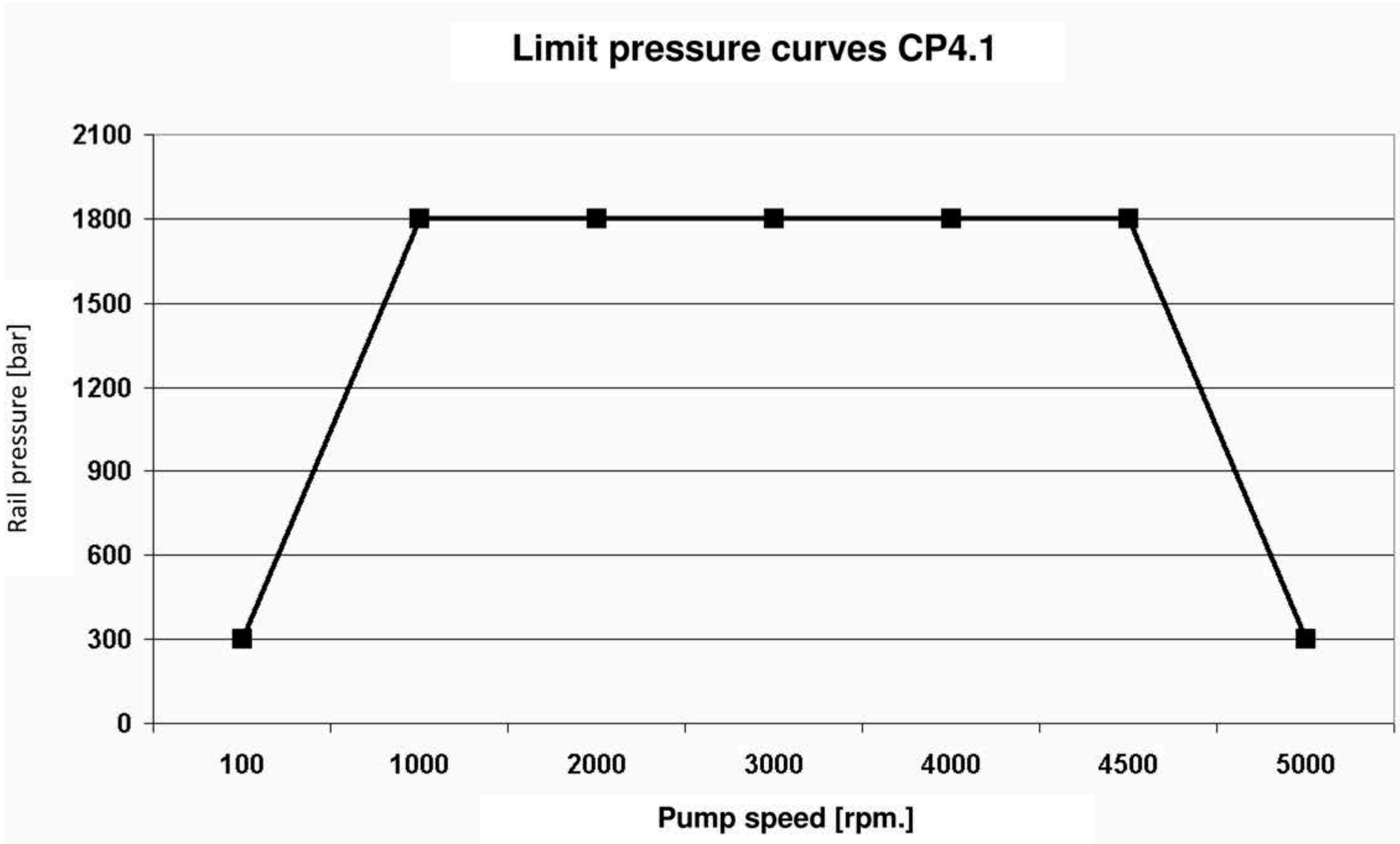
VW-R4_2.0l_low: Notes on initial commissioning

Table 1:

Pump rotation speed [1/min]	100	1000	2000	3000	4000	4500	5000
Pump rotation speed [1/min]	100	1000	2000	3000	4000	4500	5000
Rail pressure [bar]	300	1800	1800	1800	1800	1800	300

Diagram 1:



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VW-R4_2.0l_low: Notes on initial commissioning

1) LP/HP venting:

Continue filling the high-pressure fuel pump at a standstill until no further air bubbles are visible in the CP return or overall return. (transparent inlet and return lines recommended).

Notes: MU flow-free open; PCVu flow-free open; more efficient venting through back pressure-free total return bottom/top Predelivery pressure > 4.5bar_abs.

2) Safe venting of HP part:

Depending on the configuration tolerance of suction/HP valve, possibly already completed in step 1 through EFP admission pressure.

Venting of suction/HP valve of CP4 by turning the high-pressure fuel pump with open (flow-free) PCVu until PCVu return is free of air bubbles.

→ System venting is complete; the system is ready for operation.

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VW-R4_2.0l_low: Note on initial commissioning

For cold test commissioning:

3) Measurement of rail pressure fluctuation
i.e. test whether correct venting occurred or measurement of air incurred during venting.

4) Test (e.g. test of high-pressure seal)
with e.g. 1600bar rail pressure and a pump speed of 1500 1/min. (i=1→ $n_{CP} = n_{Engine}$). Proposal: Duration^{U*} 30sec.

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VW-R4_2.0l_low: Note on initial commissioning

Proposal: Check HP seal in pure PCV operation (due to venting; better through PCVu)
MU test: Function test through temporary closing of MU → Monitor pressure range (MU_{TV}=100%; not clocked; continuous flow <1.7±0.1A)

At the end of the cold test, the fuel must remain in the system. To transport the engine, seal the inlet and return connections of the injection system tightly with plugs, since HP and LP system are short-circuited with flow-free PCVu. This is intended to prevent leakage of the system, particularly emptying of the rail.

Note: Filling of leakage rail not supported in cold test; only in first start or hot test. Filling takes place through the control volume of the injectors during injection.

VW-R4_2.0l_low: Note on initial commissioning

No.	EKP [bar absolute]	CP4-return pressure [bar absolute]	CP4-Speed rpm	Rail pressure [bar]	Pressure control valve u	Metering unit	Remarks	Min.-duration [sec.]	Max. duration [sec.]
1	min. 4.5	1.0 – 1.2 max. 1.8 U*	0	-	opened I = 0A	opened I=0A	CP LP/HP venting with electric fuel pump preliminary pressure CP supply: ensuring the fuel lubrication and venting of the overall system until CP return bottom/top pressure control valve u return is free from bubbles	U*	-
2	min. 4.5	1.0 – 1.2 max. 1.8 U*	Start max. 300	0	opened I = 0A	opened I=0A	For reliable venting after intake/HP valve ventilation of the HP Hpart until pressure control valve u return is free from bubbles	U*	-
3	min. 4.5	max. 1.8 U*	Start max. 300	Start (250)	controls	opened I=0A	•Ventilation check i.e. measurement of the rail pressure fluctuation •.If the start pressure is not achieved with stability after 60 s, cancel the test	To be calculated	≤180 U*
4	min. 4.5	max. 1.8 U*	See Table1	See Table1	controls	opened I=0 ... 0.7A	Leakage test (temperature increase pressure control valve u return)	-	30 U*

Proposal: Customer coordination of initial commissioning at vehicle plant with RB. The variables marked with a **U*** are currently being defined.

VW has yet to define definitive low-pressure configuration.(Pages 11,12).

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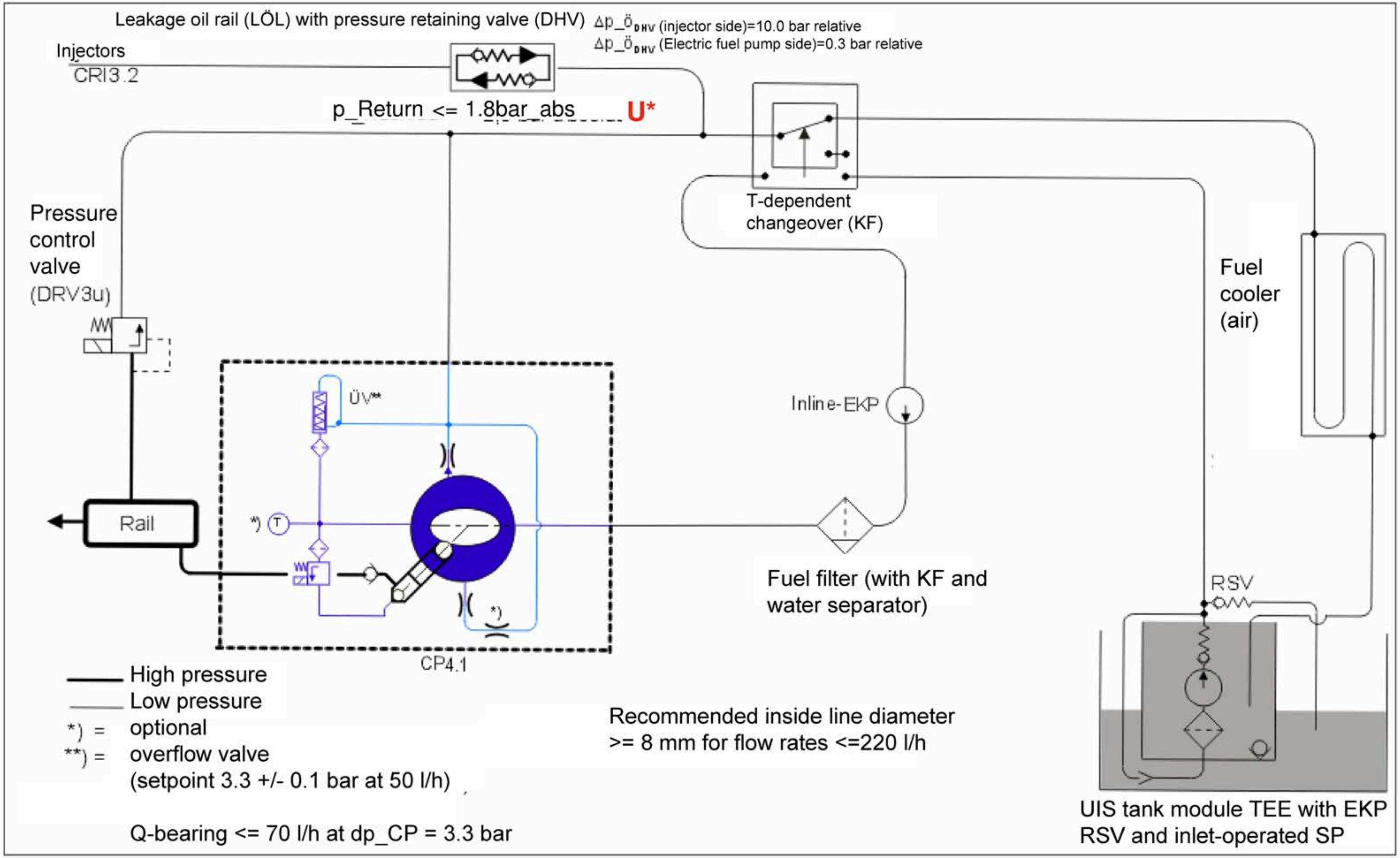
VW-R4_2.0l_low: Note on initial commissioning

Note in case of air intake to the LP system before CP4:

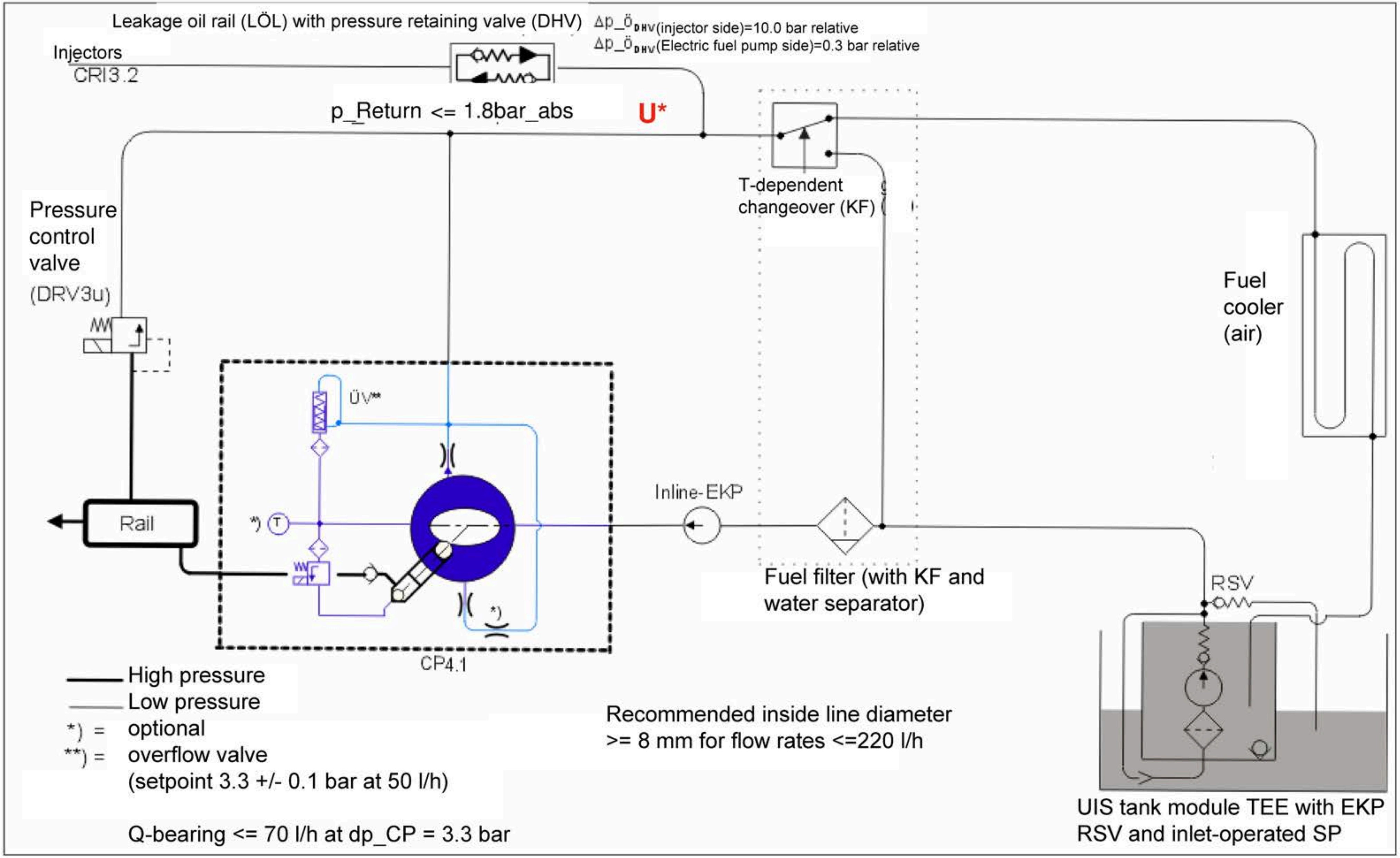
If an air column is delivered to the CP4 (e.g. restart after empty tank, through cutting off CP inlet, after filter change) the CP4 cannot deliver the air column to the rail if the PCVu is closed; no pressure build-up is possible.
In this case, the PCVu must be flow-free, i.e. open; only then can the air column be routed through the CP piston to the rail, and then through the PCVu. If CP4.1 is not critical since it is detectable → no pressure build-up possible.

→ SW is available for this purpose in the vehicle **U***.

Version 2: CP4.1 + inline EFP before Filter



Version 3: CP4.1 + inline EFP after Filter



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EA11003EN-00183[0]

From: [redacted]
To:
CC:
Date: 5/26/2008 4:40:14 PM
Subject: FW: Abridged minutes for on-site meeting on 23/04/2008, Audi [redacted] exemplary measurement of cold and hot test operation for R4, 2.0-lire engine
Attachments: Inbetriebnahme_CP4_Audi [redacted] 100408.pdf
7900875d_Zu_000_VW-R4_2.0l_Hinweise zur Erstinbetriebnahme von CRS3.2.pdf
EHP2_4144_VN5881_Auswertung_Kalttest [redacted] Tr.pdf
Triebwerkschaden .xls
EHP2_4148_VN5881_Auswertung_Hottest [redacted] Tr.pdf

Dear [redacted]

I hope that you are feeling much better!

Since your mailbox was full, please find attached once again the minutes from our joint meeting regarding measurements on the R4 2.0-liter cold and hot test in [redacted].

Mit freundlichem Grüssen /Best Regards

[redacted]

Robert Bosch GmbH
[redacted]
70049 Stuttgart
www.bosch.com
[redacted]

From: [redacted]
Sent: Wednesday, May 07, 2008 3:15 PM
[redacted]
Cc: [redacted]
Subject: Abridged minutes for on-site meeting on 23/04/2008, Audi Györ,exemplary measurement of cold and hot test operation for R4, 2.0-liter engine

Abridged minutes for on-site meeting on 23/04/2008, Audi [redacted],
<u>Exemplary</u> measurement of cold and hot test operation for R4, 2.0-liter engine by Bosch

TN:
Audi: [redacted]
Fröhlich:
Bosch:

*=temporarily

during the 3rd Audi zero-malfunction-discussion on 10/04/2008, the joint recommendation for next steps to record actual developments in the cold and hot test rigs

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Bosch points on initial operation R4, 2.0-liter engine

Non-responsive content removed Hinweise zur Erstinbetriebnahme von CRS3.2.pdf>>

22/04/2008, Bosch arrival 14:30,

Instrumentation of a CR engine in cold test upgrade area

Engine cold test:
Engine no. CAG 058018
CP4.1 pump: 04 100 408
BPT 0360

23/04/2008, measures for cold test test rig no. 2, from 08:00

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23/04/2008, 12:45, telecon on results of cold test measurements:

1. so far 4 - 5 cold test measurements taken
2. at first glance, cold test operation for normal operation i.O. Detailed analysis measurement data still required.
3. Required optimization:
   1. Initial start cold test operation with PDE programme instead of CR cold test programme;
      Test rig interrupted (manually or automatically?);
      Analysis: Engine working parts carrier bears CR engine no. card
      Mobi data shows CR engine no.
      Mobi data cold test test rig shows PDE engine data (BXE...)
      For engine type change (PDE-CR/CR-PDE) mu?? Connector plugs on test rig changed manually. This was forgotten.
      Proposed remedy: Connector plug identification prior to start of cold-test test run

   2. CR test programme also starts with non-inserted DRV connector plugs; since measurement window only checks rail pressure at the end of stage 3. CP4.1 is dragged for at least approx. 20 seconds without rail pressure with high engine speed. Repeat cold test if error not identified.
      possible. Cable harness identification has not yet been introduced due to cycle time. Proposed remedy: Cable harness identification for DRV and RDS prior to start of cold-test test programme

   3. As far as can be seen, pump supply and return hoses are not fitted correctly to the engine
      Pump supply and/or return hose from exhaust gas closing plate with hydraulic cylinder
      can be pressure tested. Reappeartest shows slight decrease in supply and return pressure.
      Proposed remedy: Measurement/observation of exhaust gas pressure at the start

   4. Flow rate CP4.1 supply in cold test test rig 3. smaller than Bosch initial operation- specifications v. 135 - 200l/h.
      Proposed remedy: Installation of larger feed pumps on cold-test test rig 2.,3. and 4. analogue cold-test test rig 1.

   5. Register termination criteria in target-cold-test-target-process R4 2.0-liter and in the SET synchronize test engineering
      V Audi: Non-responsive content removed

   6. Insight into the installation protocol of the three failed engines in [redacted] in the cold test

Audi doesn't allow any direct insight into the engine installation protocol during on-site meeting.
Please find attached the data provided by Audi (1 engine missing).
<<Triebwerkschaden .xls>>

Summary from detailed analysis of the cold test measurement display:

- Supply level with 100 l/h too low (according to instruction min. 135 l/h); with 135 l/h it's surely much better ventilated and the time until rail pressure formation is minimized
- the CR engine can also be driven in the PDE programme (here the pump does not falter)
- if the DRV connection plug is removed, the entire operation can be run without rail pressure
- whilst the blow-out phase increases return return pressure, i.e. low differential pressure and therefore low blow-out function

Important open points regarding cold test:

- how often can the cold test be repeated before the engine looks striking?
  (above all if for example it is dragged 3 - 5 times with DRV removed, then the DRV is inserted and the engine is OK)
- in the current measurements from [redacted] there were no amounts and no faults reproduced
- the CP4.1 pump, with which the cold test operation was measured goes to Bosch for diagnostics/analysis
  V: DS-PC/EHP T: asap

23/04/2008, measurements for hot test, cabin no. 3, from 14:00

Engine no. CAG 051 535
CP4 pump: 01 070 408
BPT 0620
Used engine in the leak test not OK

Measurements for hot test:
[redacted]

Summary from detailed analysis of the hot test measurement display:

- for normal operation (pump OK, bonding OK etc), the hot test is carried out without complaint
- if, for example, you remove the DRV you can drag with rail pressure 0 and 1000 1/min as long as you want
- no observation ascertainable, which switches off the test rig in the case of a failure
- how often the hot test can be repeated in the case of a failure is unclear
- compared to the Bosch measurements 1.5 years ago no change found in the hot-test test sequence with removed DRV connection plug

Overall summary:

With correct handling in automatic drive (correct bonding, correct test programme, no other defects)

the cold and hot test operations are OK.
However, the procedure in the case of failure is not defined (max. trail duration without rail pressure, max. acceptable number of repetitions, etc) and with that, possible damage to the high-pressure fuel pump is conceivable.

Further points for clarification:

Clarification necessary observation of start-up of Audi engines in Audi/VW vehicles so far not carried out

(R4, 2,0l in A3 Cabrio u. [redacted]
V: Audi, [redacted]

Mit freundlichem Grüssen /Best Regards

[redacted]

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VW-R4 2.0l EU5

– CRS3.2 –

Notes on initial commissioning of CRS with CP4.1 and predelivery inline EFP in connection with cold test inspection

1/14/2008

Notes:

This slide replaces the slides **14121d_Zu** {12/01/05} and **14150d_Zu** {12/09/05};

14911d_Zu {03/14/06} [changes marked in “red”]

6860199d_Zu {06/27/06} [changes marked in “blue”]

6870329d_Zu {08/02/06} [changes marked in “green”]

6890468d_Zu {09/13/06} [changes marked in “pink”]

6900721d_Zu {10/31/06} [changes marked in “light green”]

6900721d_Zu {5/14/07} [changes marked in “light blue”]

Values marked with U are defined; the “U” indicator was deleted.

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

To note during assembly:

→ Cleanliness requirements, particularly for supply lines to diesel fuel filter.

→ Installation and service notes.

→ Installation requirements (e.g. tightening torque), also see respective component TCDs and proposal drawings.

Initial filling of injection system

→ All TCD values must be followed!

→ Recommended filling fluid: Diesel fuel compliant DIN EN590, however HFRR ≤ 400µm

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Test to detect "gross leakage" from fuel system

To detect gross leakage prior to initial commissioning in the cold test inspection, a pneumatic leak test can be performed beforehand.

Background: For safety, health, and cleanliness reasons, the fuel system should be checked for gross assembly errors (such as incorrect screw connections) before it is filled with diesel fuel on the cold test bench.

Pneumatic leak test of the injection system:

The fuel system can be tested with air* in the CP4 inlet with pressure-free total return with a **standing** high-pressure fuel pump with **5bar_rel** for $t_{max.}$ <30s.

***Page 17**

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Recommendation <u>before</u> venting, initial commissioning, and cold test:

→ Perform electrical check (e.g. CRI3.2: contacting, capacity measurement for low voltages, etc. {Note: pay attention to line lengths and resistances of connectors})

Venting of CR system is performed for
- The low-pressure circuit through the CP4 return
- The high-pressure valve (CP4, rail) through suction or HP valve, through the PCVu in total return.

For cold test commissioning

→Activation does not take place through engine starter → Engine test bench control is needed (Activation of PCVu, MU; CRI3.2 should not inject)

VW R4_2.0l: Notes on initial commissioning of CRS3.2

Venting high-pressure fuel pump CP4 (without CP) with predelivery EFP

Note the following conditions when venting the CP4:

→ Dry running of the high-pressure fuel pump **is not allowed!**

→ Minimum filling/pre-pressure of ≥ 4.5bar_abs must always be ensured through predelivery EFP:

→ **Inlet pressure: 4.5 ≤ p_Inlet [bar_abs] ≤ 7***

*(not a critical limit, but more is not sensible)

→ **Volume flow > 80 l/h + HP volume demand**

(Upper limit only restricted by max. inlet pressure)

→ **Differential pressure between CP inlet and return:**

$p_{In} - p_{Re} \geq$ 3.4bar_rel

→ Max. **return pressure ≤ 2.0bar_abs**

(continuous running >2.0bar_abs may result in damage to shaft seal).

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

→ At **0bar rail pressure max. drag speed is n_{CP}=300…1000rev/min.** (RB recommendation n_{CP}=500…1000rev/min.)

- ➔ An important prerequisite for venting the C4 is that the rail pressure is near zero.
- ➔ If there is standing pressure in the rail, not even the compression ratio of the elements may be enough to deliver the air.
- ➔ In this case, the only venting path is through the HP piston guidance in the interior, which can take a long time.
- ➔ If rail pressure is zero, a necessary pressure differential of **3.1 ≤ Δp [bar_rel] ≤ 5.1** over **suction and HP valve results.**
- ➔ Since the **OV** is set to approx. **3.3 bar_rel** an EFP without rotating CP4 can only be vented if the tolerance values of the SV/HP valves are minimal.

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

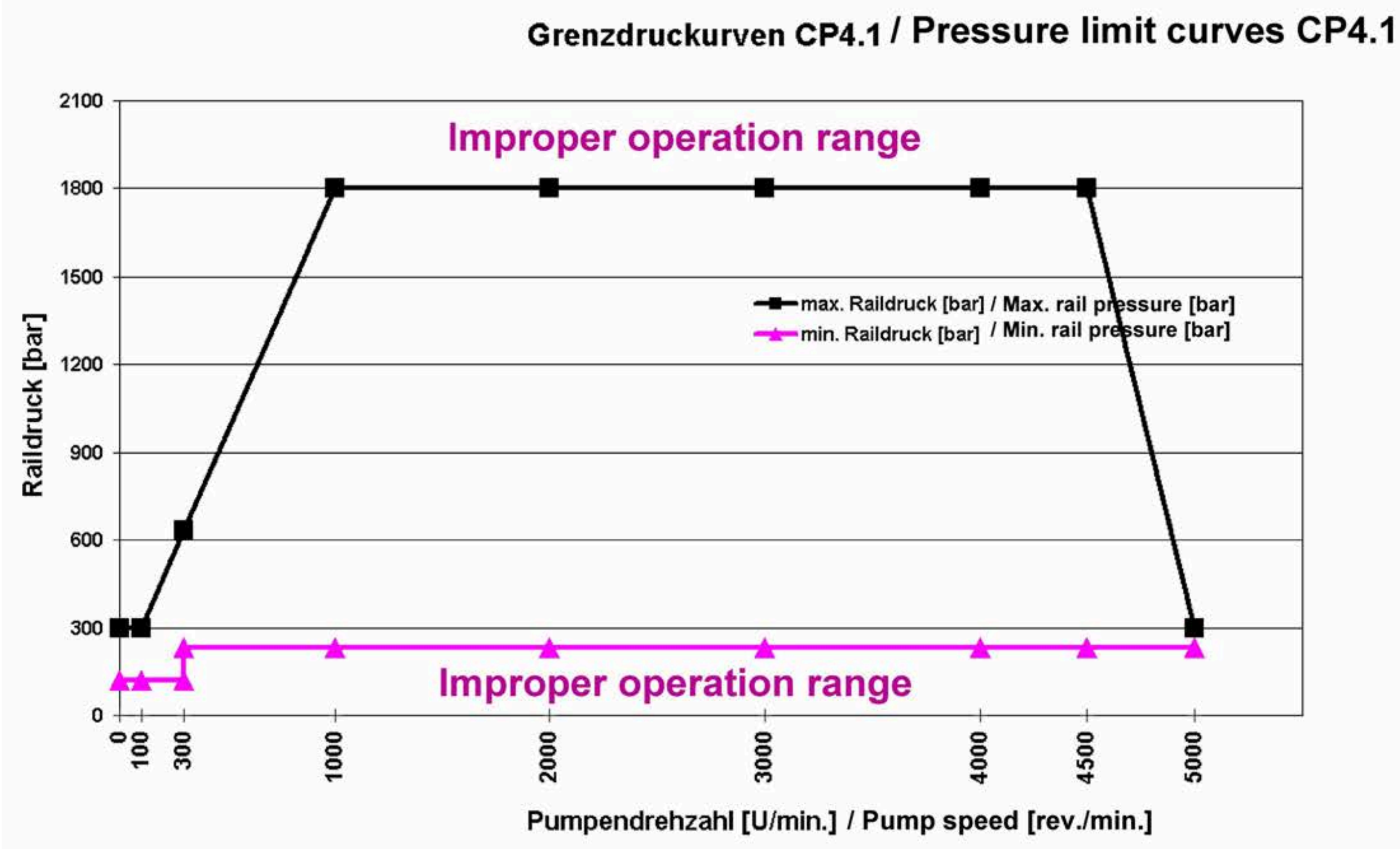
→ Operation of pump only permitted with **pressure limit curve CP4** (Tab.1, Diag.1).

Table 1: Transmission behavior [engine : pump] i= 1

Pump rotation speed [1/min]	0	100	300	300	1000	2000	3000	4000	4500	5000
Engine rotation speed[1/min]	0	100	300	300	1000	2000	3000	4000	4500	5000
Max. rail pressure [bar]	300	300	633	633	1800	1800	1800	1800	1800	300
Min. rail pressure [bar]	120	120	120	230	230	230	230	230	230	230

Diagram1:

Rail pressure [bar]



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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Step 1) LP/HP venting:
Continue filling the high-pressure fuel pump at a standstill until no further air bubbles are visible in the CP return or overall return. (transparent inlet and return lines recommended).
Notes: UM flow-free open; PCVu flow-free open; more efficient venting through back pressure-free total return bottom/top Predelivery pressure >4.5bar_abs

Step 2) Safe venting of HP part:
JDepending on the configuration tolerance of suction/HP valve, possibly already completed in step 1 through EFP admission pressure.
Venting of suction/HP valve of CP4 by turning the high-pressure fuel pump with open (flow-free) PCVu until PCVu return is free of air bubbles.

→ System venting is complete; the system is ready for operation.

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Venting steps in detail:

Step 1) Venting time without revs: **10**(…20*)**s**

(this makes the low-pressure area safe; the high-pressure area is only conditionally vented, depending on the tolerance situation of the SP/HP valves.)

and

Step 2) Venting time at speed(**300 ≤ n_{DRAG}[min.$^{-1}$] ≤ 1000***)

after pre-venting of LP area: **= 5 to max. 10s**

→ max. allowed pos. of CP4 speed gradient: **400rev/min./s**

→ For **step 1) + 2)** essential: p_Rail=0 bar

Caution: **Step 2)** with p_{Rail} = 0bar or flow-free PCV is restricted to max. 10s!

→ Danger of pump damage in new condition

From **step 3)**, p_{Rail} ≥ 230bar is essential!

*RB-recommendation

VW R4_2.0l: Notes on initial commissioning of CRS3.2

Venting cold test commissioning at engine plant

Step 1) Pre-venting of CP4.1 LP area

Q_{Inlet}	= 135 – 220 l/h (EFP or test bench supply)
Alternative	
p_{Inlet}	≥ 4.5 bar_abs (≤ 7 bar_abs); RB recommendation:: 5.0 bar_abs further increase p_{Inlet} increases Q_{Return} by 400 l/(h*bar)

$p_{Inlet} - p_{Return} \geq$ 3,4 bar_rel [= $p_{Diff.-CP}$ at $Q_{Return} \geq$ 80 l/h]

p_{Return}	≤ 1.8…2.0 bar_abs (static)
$t_{Venting}$	≥ 10 sec. (pure CP venting time)
n_{Pump}	= 0 min^{-1} (pump at standstill [!])
p_{Rail}	= 0 bar_rel (bel. to p_{Return}), PVCu open, that is, without flow [!]

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Step 2) Final venting CP4.1 HP area

Q_{Inlet}	= 135 – 220 l/h (EFP or test bench supply)
Alternative	
p_{Inlet}	≥ 4.5 bar_abs (≤ 7 bar_abs)
p_{Return}	≤ 1.8…2.0 bar_abs (average pressure)
$t_{Venting}$	= 5 to max. 10 sec. [caution: Danger of pump damage in new condition!]
n_{Pump}	= 1000 min^{-1} (→ max allowed pos. of CP4 speed gradient: 400rev/min./s)
p_{Rail}	= 0 bar_rel (rel. to p_{Return}), PCVu open, that is, without flow [!]

Times must be determined through trials directly on the ending in the final function test (FFT).

→ System venting is complete; the system is ready for operation.

→ Do not operate further without min. rail pressure [p_{Rail} ≥ 230 bar]

→ Otherwise danger of pump damage in new condition!

→ During the first revving up of the CP4, max. allowed pos. CP4 speed gradient: 400rev/min./s

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Tests for cold test commissioning:

Step 3) Measurement of rail pressure fluctuation
i.e. test whether correct venting occurred or measurement of air incurred during venting. [Caution: min. Railpressure $p_{Rail} \geq 230$ bar]

Step 4) Test (e.g. test of high pressure seal) → $p_{Rail} \geq 230$ bar
with e.g. 1600bar rail pressure and a pump speed of 1500 1/min. (i=1 → $n_{CP} = n_{Motor}$). Proposal: Duration 30 sec.

After step 4), the system can be operated as in the vehicle. When shutting down the engine, the
max. allowed neg. CP4 rev gradient is: -1800rev/min./s
(the transmission behavior [CP:Motor] must be observed.)

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Proposal: Check HP seal in pure PCV operation (due to venting; better through PCVu)

MU test: Function test through temporary closing of MU -> Monitor pressure range (flow max. 1s with 1.7±0.1A; not clocked)

At the end of the cold test, the fuel can remain in the system. It is possible to empty the CP incl. inlet and return lines through blowing out* (e.g. air). [Description Page 15] To transport the engine, seal the inlet and return connections of the injection system tightly with plugs, since HP and LP system are short-circuited with flow-free PCVu. This is intended to prevent leakage of the system, particularly emptying of the rail.

Note: Filling of leakage rail not supported in cold test; only in first start or hot test. Filling takes place through the control volume of the injectors during injection.

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Venting steps in detail:

No.	EFP [bar_abs]	EFP [bar_rel]	CP4 return - back-pressure [bar_abs]	CP4 speed [rev/min.]	Rail pressure [bar]	PCVu	MU	Remarks:	Min. duration [sec.]	Max. duration [sec.]	$Q_{ReC.Max.}$ [l/h] (Test bench inlet)
1	min. 4.5 RB rec. 5.0	min. 3.5 RB rec. 4.0	1.0 - 1.2 max. 2.0 Caution: $p_{Inl.}$-$p_{Ret.}$≥ 3.4bar_rel	0	0	opened *I=0A*	opened *I=0A* *(allowed max. flow 1.7A±0.1 A not clocked max. 1 sec.)*	Venting at standstill: CP LP venting with EFP admission pressure CP inlet; ensure fuel lubrication and venting of entire system to CP return bottom/top PCVu return and overall return free of air bubbles	10	Unlim. RB rec. 20	4, 6, 8cyl. 350l/h @ 4.0bar_rel
2	min. 4.5	min. 3.5	1.0 - 1.2 max. 2.0	(300...) 1000	0	opened *I=0A*	opened *I=0A*	For safe venting, from suction/HP valve venting of HP part to PCVu return free of air bubbles	5	10	4, 6, 8cyl. 210l/h @ 3.5bar_rel
3	min. 4.5	min. 3.5	max. 2.0	(300...) 1000	Start (≥ 230)	regulate	opened *I=0A*	• Venting check, i.e. measurement of rail pressure fluctuation • if, after 10sec., a stable starting pressure is not reached, cancel test	to determine	≤ 180	4, 6, 8cyl. 210l/h @ 3.5bar_rel
4	min. 4.5	min. 3.5	max. 2.0	pressure/ speed table 1	pressure/ speed table 1 (≥230)	regulate	opened *I=0 ... 0.7A*	Leakage check (temperature increase PCVu return)	- - -	30	4cyl.-245l/h, 6cyl.-260l/h, 8cyl.-300l/h @ 3.5bar_rel

Note: The following applies to steps 1 through 4: max. allowed pos. CP4 rev gradient: **400rev/min./s;** max. allowed neg. CP4 rev gradient:: **-1800rev/min./s;** $p_{Inl.}$ - p_{Ret} ≥ **3.4bar_rel**

<u>Proposal:</u> Customer coordination of initial commissioning at vehicle plant with RB.

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Optional:

Emptying of CP through blowing out* (e.g. air) after cold test commissioning:

$p_{Inlet} \leq 2.8$ bar_rel
$-0.2 \leq p_{Return}$[bar_rel] ≤ 1.0

$t_{Blowout} \leq 30$ sec.
$n_{Pump} = 0$ min.$^{-1}$ (pump at standstill)

Background: Avoid emptying rail volume through CP and PCV.

$p_{Inlet} \leq 5.0$ bar_rel, when PCV is closed, e.g., while under flow during blowout process.

*Page 17

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VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Note in case of air intake to the LP system before CP4:

If an air column is delivered to the CP4 (e.g. restart after empty tank, through cutting off CP inlet, after filter change) the CP4 cannot deliver the air column to the rail if the PCVu is closed; no pressure build-up is possible.
In this case, the PCVu must be flow-free, i.e. open; only then can the air column be routed through the CP piston to the rail, and then through the PCVu. If CP4.1 detectable -> No pressure build-up possible.

-> SW is available for this purpose at the Fhz.

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

If **air or gases**, are used, there is a hazard of contamination and water intake.

The cleanliness requirements with regard to air must be followed:

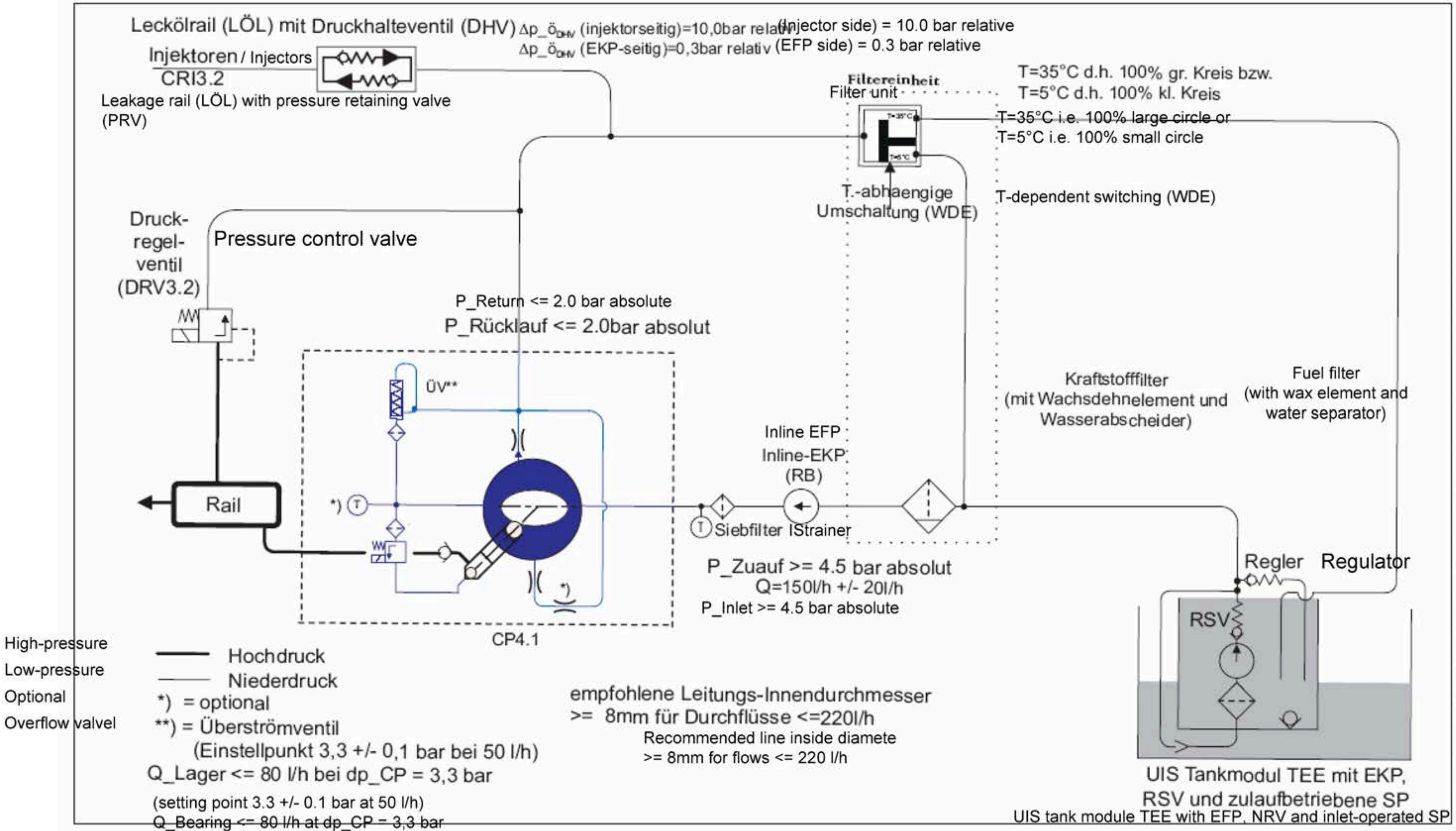
→ **The air supply must be free of water and oil.**

→ **The use of a 0.3µm filter to separate solid contaminates from compressed air and gases is necessary.**

RB recommendation: Series filter connection with 5µm [rough] and 0.3µm filter.

VW-R4_2.0l: Notes on initial commissioning of CRS3.2

Common Rail System (CRS3.2 - 1800bar mit CRI3.2, CP4.1 mit Tank- u. Inline-EKP nach Filter)
Niederdruckkreis VW_R4_2.0l_EU5/BIN5 im K-SUV/Jetta



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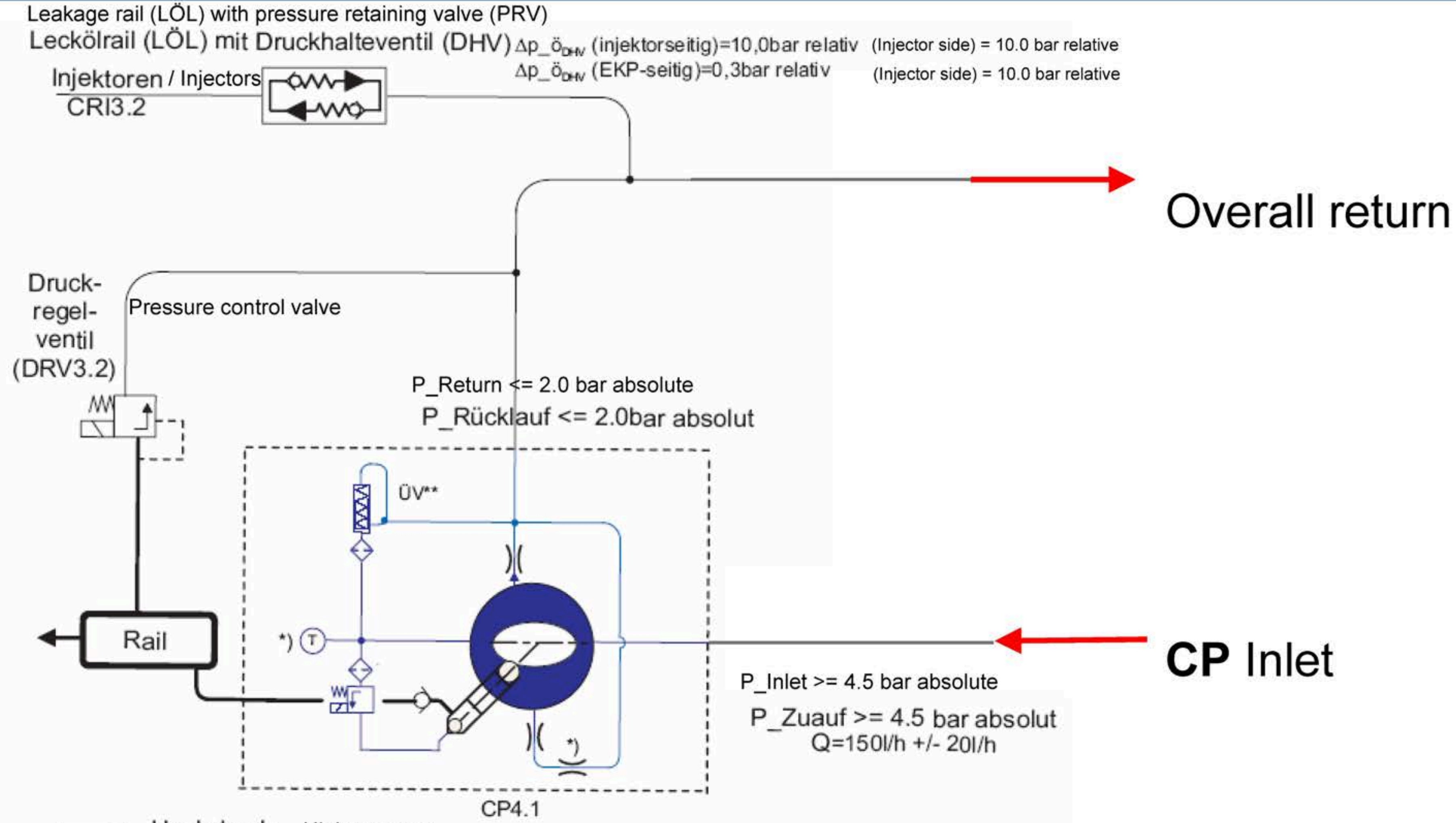
EA11003EN-00184181

VW-R4_2.0l: Notes on initial commissioning of CRS3.2



Hochdruck — High pressure

Niederdruck — Low pressure

*) = optional — Optional

**) = Überströmventil — Overflow valve

(Einstellpunkt 3,3 +/- 0,1 bar bei 50 l/h) (setting point 3.3 +/- 0.1 bar at 50 l/h)

Q_Lager <= 80 l/h bei dp_CP = 3,3 bar — Q_Bearing <= 80 l/h at dp_CP = 3,3 bar

empfohlene Leitungs-Innendurchmesser >= 8mm für Durchflüsse <=220l/h

Recommended line inside diameter >= 8mm for flows <= 220 l/h

CP4.1 Cold Test R4 EU5 Audi [redacted]

CP4

Task:

- Measure commissioning VW R4 TDI
- Measurements on **cold test bench + filling station**

Trial execution:

- **Location:** Audi [redacted] cold test bench no.2 + filling station
- **Pump assembly:** Series VW R4
- **Measured values:** Inlet and return pressure (Kistler sensors 10 cm before pump)
  engine speed with pickup on camshaft
  Rail pressure from engine RDS
  I_ZME, I_DRV with clamp meter measure
  Inlet and return volume with VSE
  Speed and inlet pressure parallel from [redacted] control cabinet

- **Measurement process:** 1. Fill the pump
  2. Engine check program (engine not fired)

- **Data recording:** LTT 186/16ch sampling rate 100 kHz

All results for pressure values in bar_rel !

CP4.1 Cold Test R4 EU5 Audi [redacted]

CP4

Results:

- Inlet volume max. 100 l/h (required 135 -220 l/h)
- Operation of pump with PDE cold test possible (connector on equipment transposed, no check as to whether connected properly)
- PCV connector disconnected, or faulty contact is not detected, therefore full test runs with rail pressure 0 bar. The number of possible repeat attempts is unclear.
- Cold test process with correct check program, intact contacts and required inlet volume is OK
- When the pump is blown out, the OV is not opened (therefore poor blow-out effect), high back-pressure (2.5 bar_rel) in return

SUMMARY:

- Damage to pump in cold test possible due to overly long dragging with rail pressure 0 bar when PCV connector/RDS is disconnected
- Inlet volume, at 100 l/h, is below the requirements of the commissioning guide-lines, if the prescribed values are increased, faster rail pressure build-up possible
- Impact of blow-out function from available measurement not optimal

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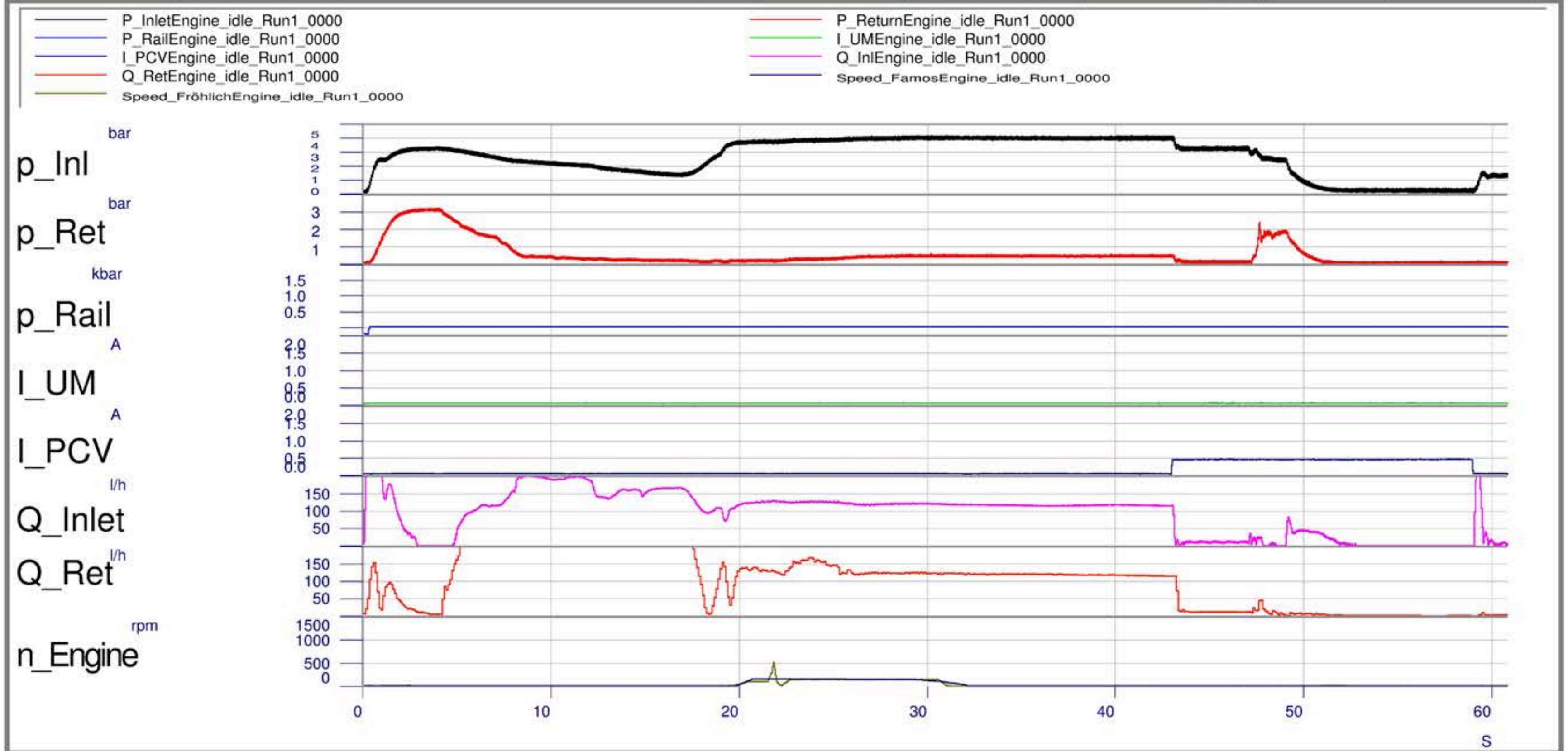
EA11003EN-00185[2]

CP4.1 Cold Test R4 EU5 Audi [redacted]

CP4

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2[redacted]		P_inlet	Approx. 4.0	bar			
	Pump empty, cold test with PDE process		T_Inlet	20	°C		[redacted]	



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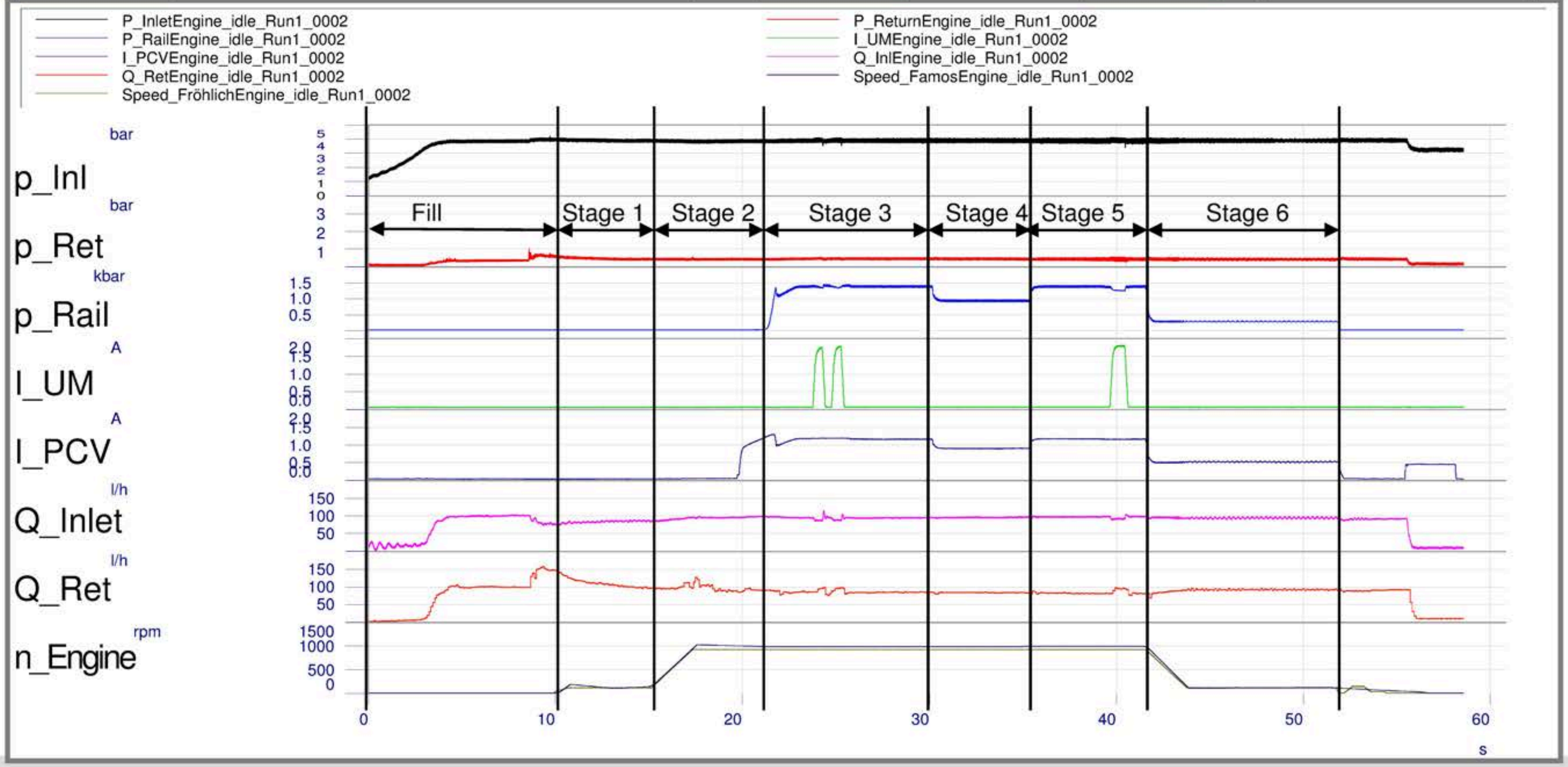
EA11003EN-00185[3]

CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

CP4

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Cold Test Common Rail Motor		T_Inlet	20	°C		DS/EHP2	



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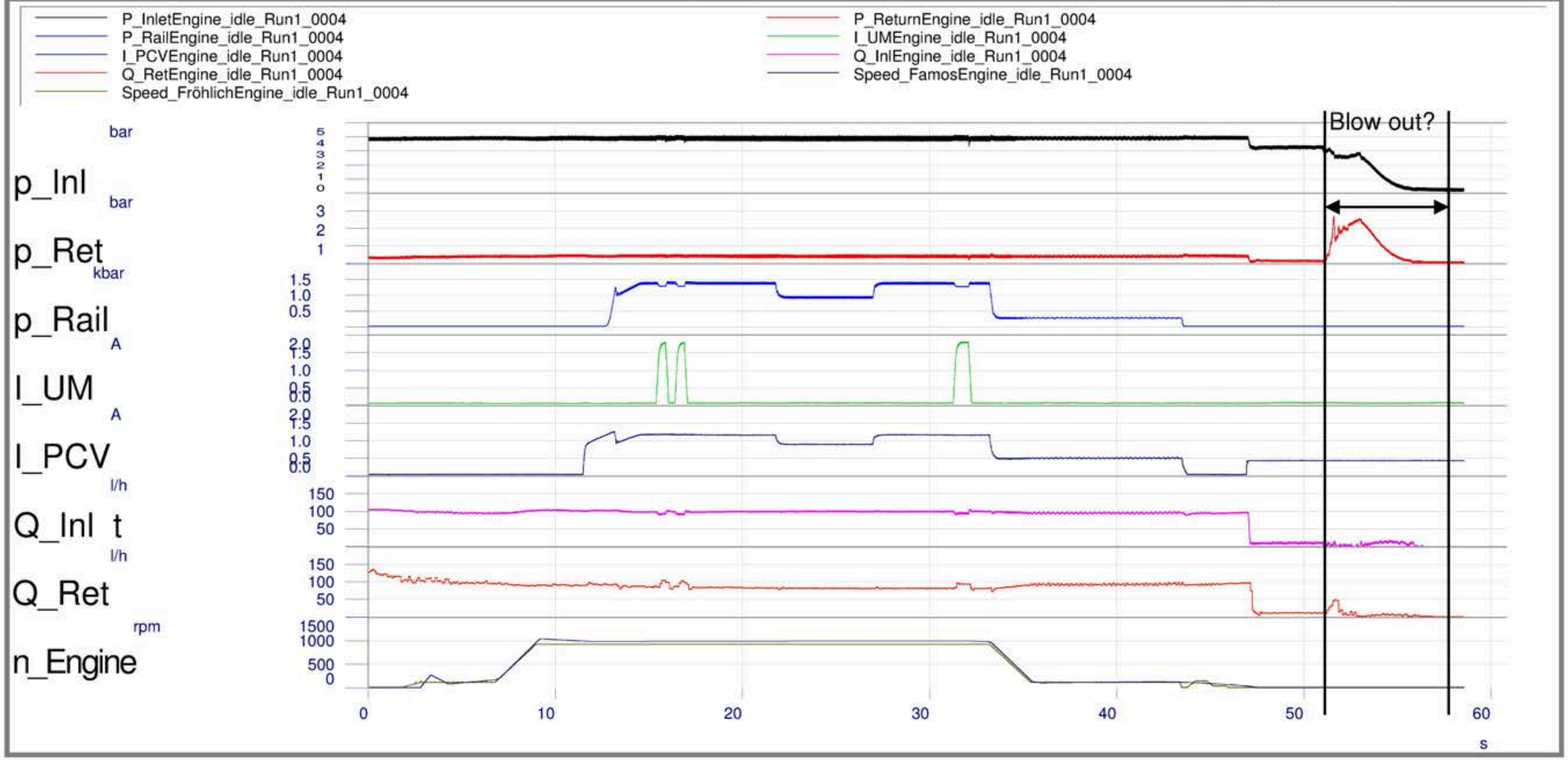
CP4.1 Cold Test R4 EU5 Audi [redacted]

Pump	CP4.1_348_2x5.25_REC_3.3_1.8	nEngine	var	rpm	done by	[redacted]
Sample	Pump 04 100 408 BPT 0360	P_Rail	var	bar_rel	date	4/23/2008
testbench	Audi cold test bench no. 2[redacted]	P_inlet	Approx. 4.0	bar		
	Pump filled, cold test	T_Inlet	20	°C	[redacted]	



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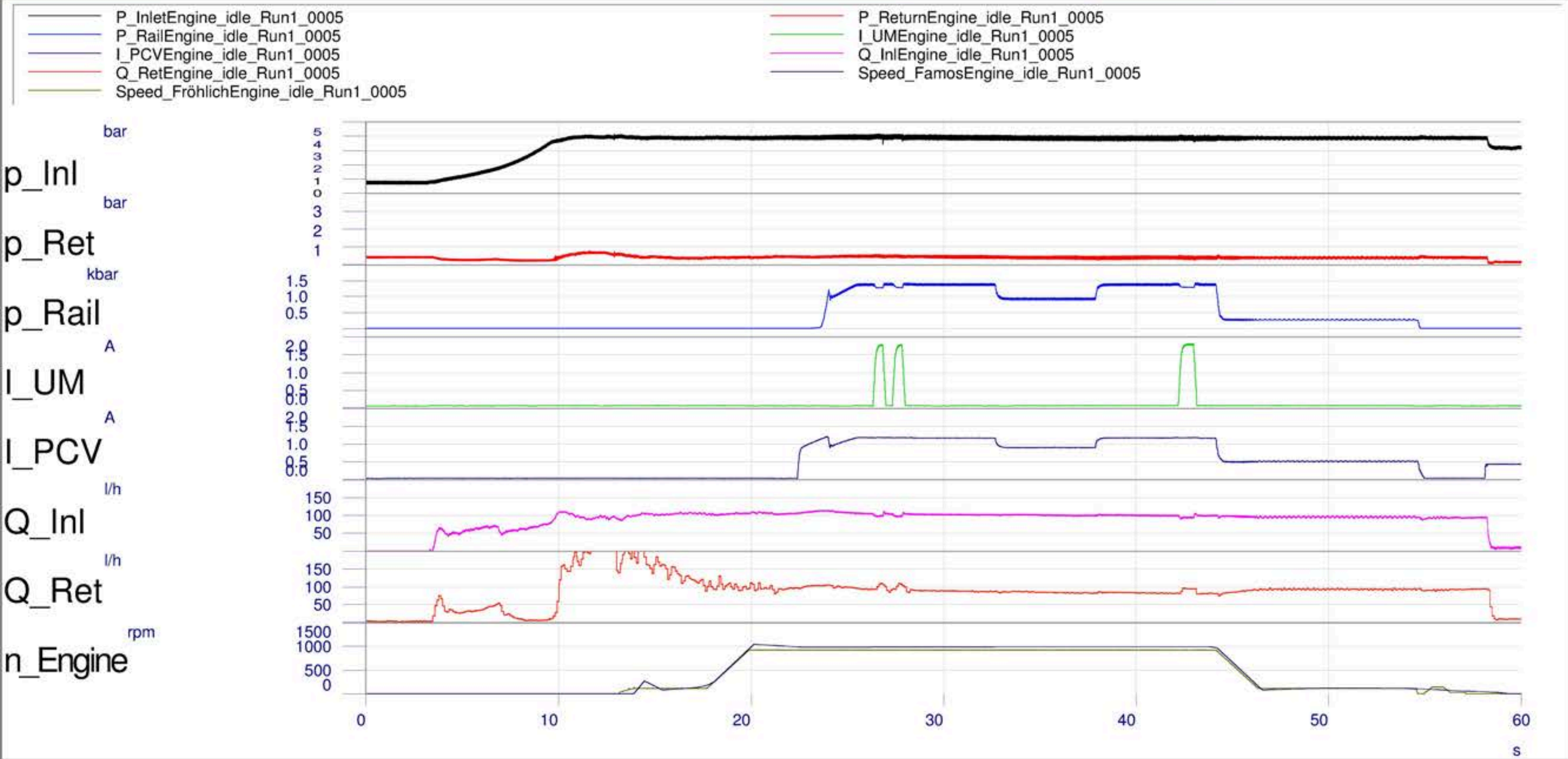
CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2[redacted]		P_inlet	Approx. 4.0	bar			
	Pump not filled, cold test		T_Inlet	20	°C		[redacted]	



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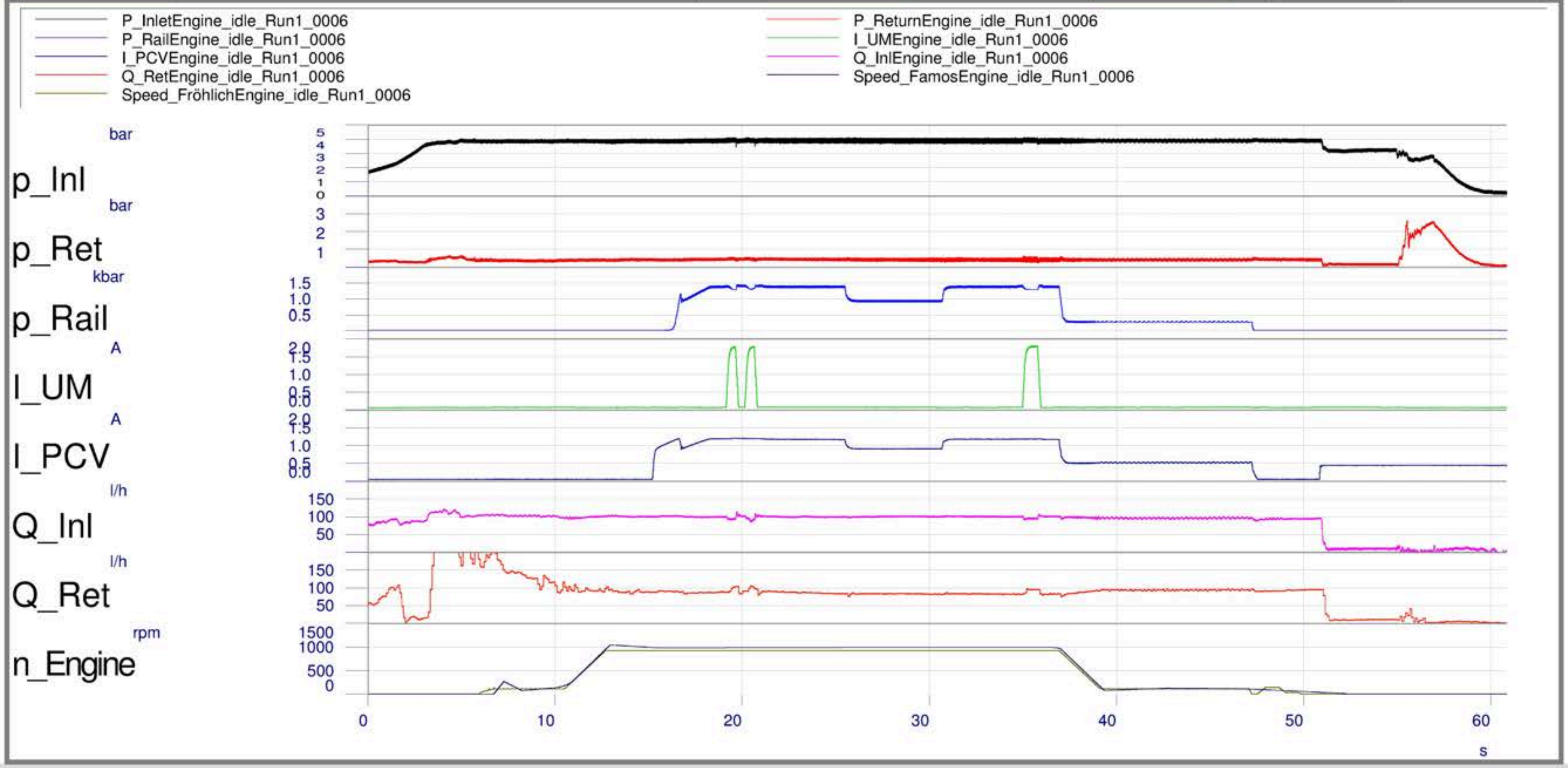
CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Pump not filled, cold test, repeat		T_Inlet	20	°C		[redacted]	



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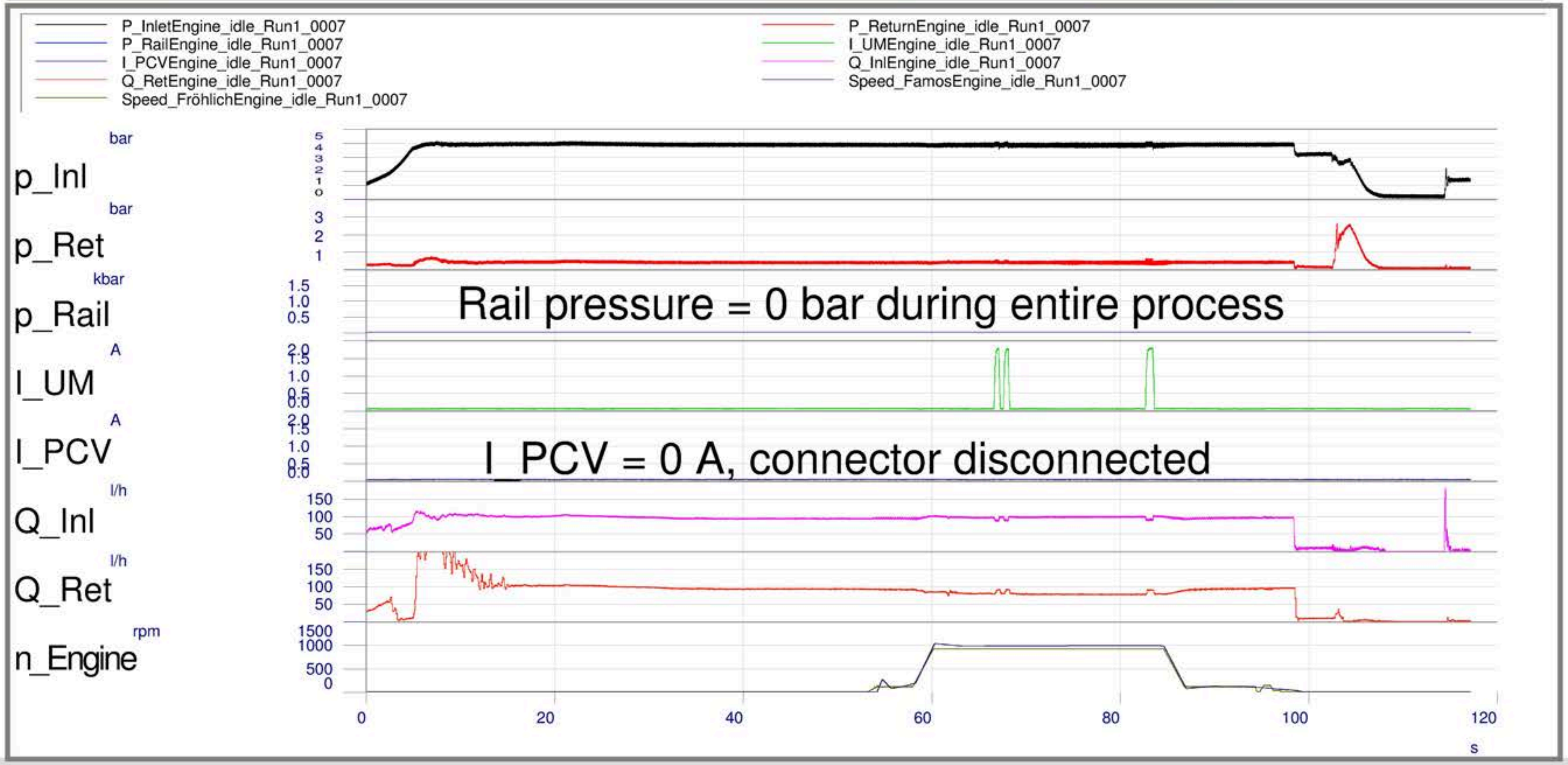
CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Cold test, PCV connector disconnected		T_Inlet	20	°C		[redacted]	



Diesel Systems

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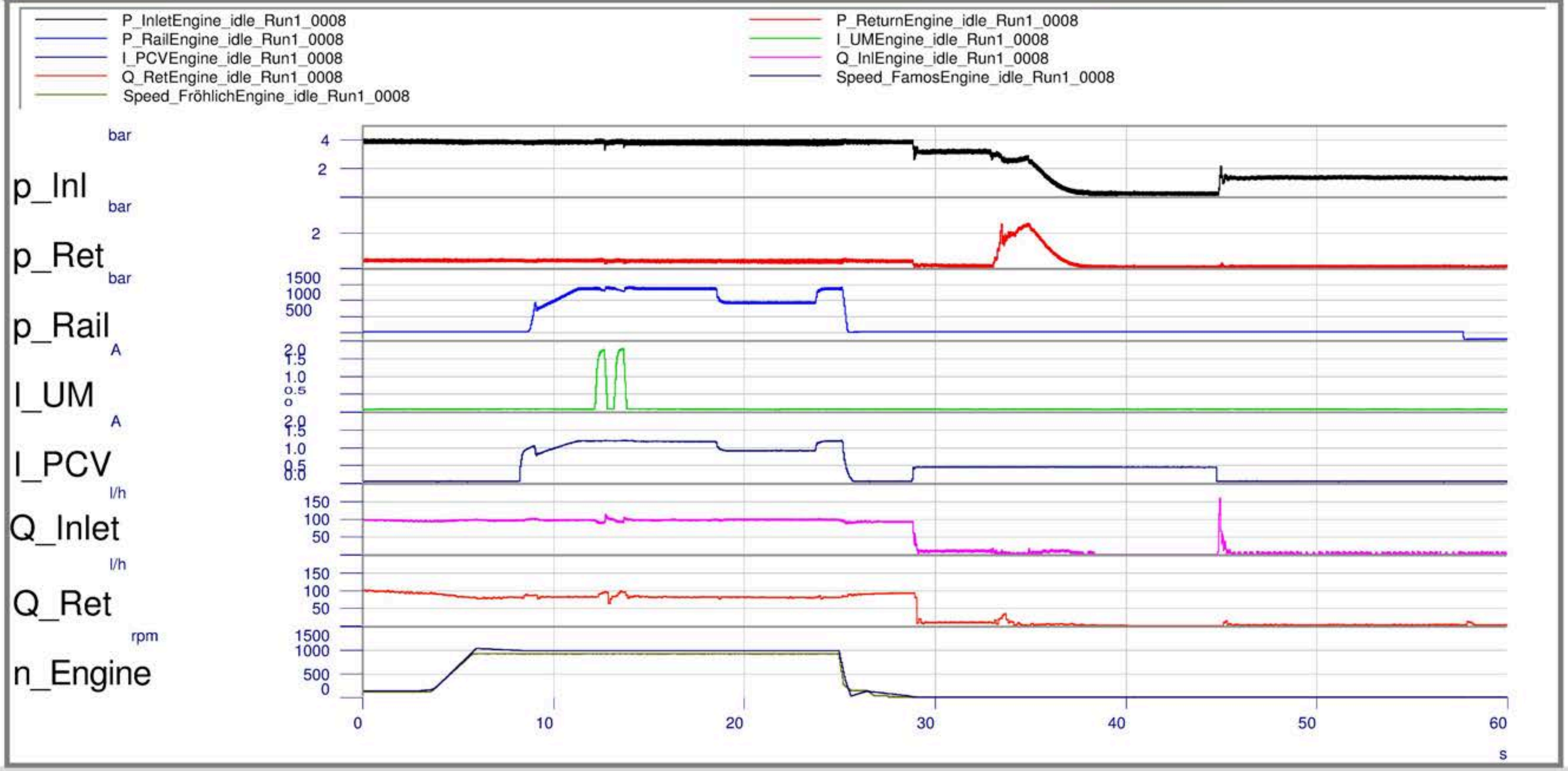
CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

CP4

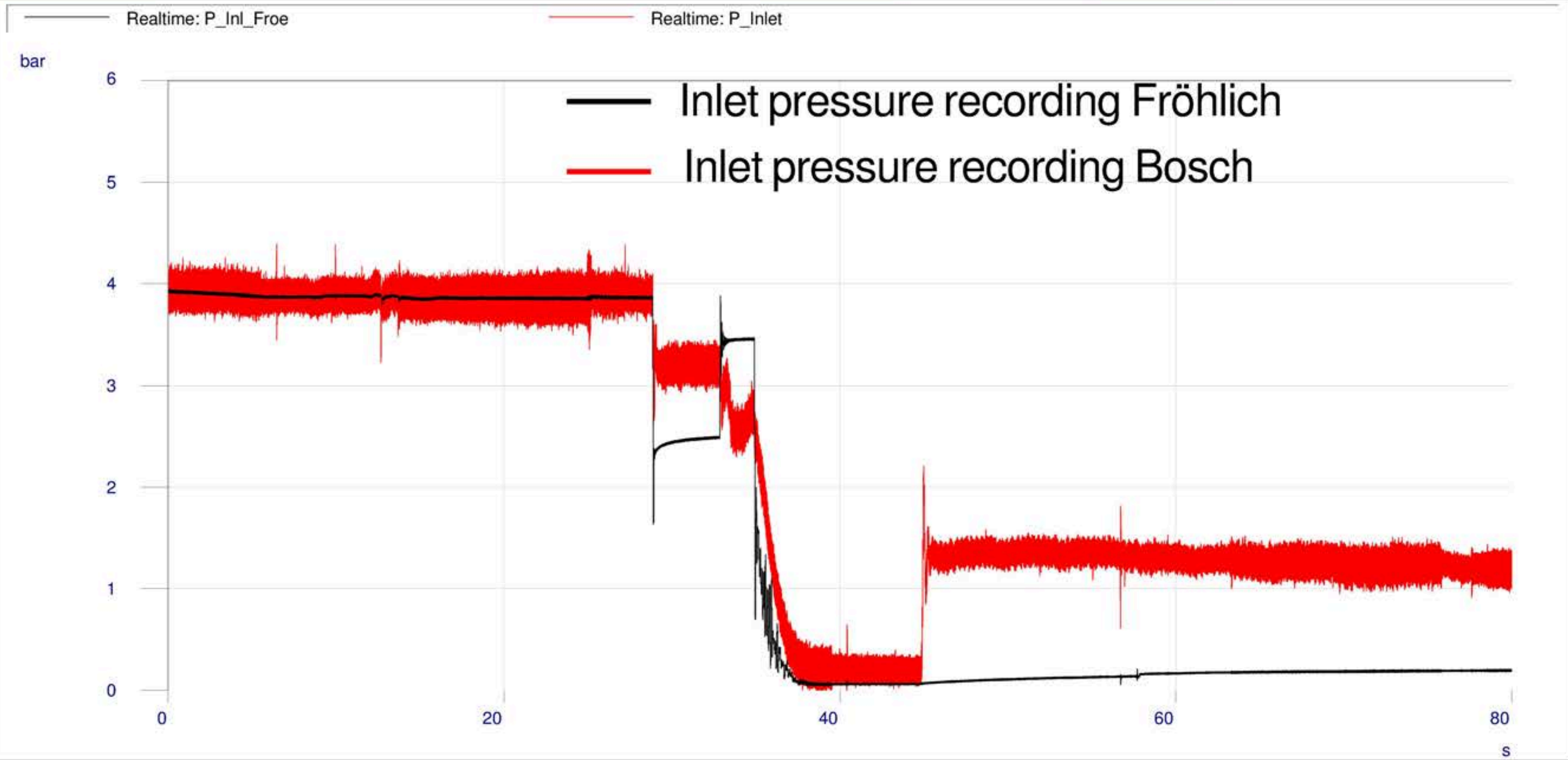
Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	var	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Cold test, inlet hose jammed		T_Inlet	20	°C		[redacted]	



BOSCH

CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	0	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	0	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Compare inlet pressure measurement		T_Inlet	20	°C		[redacted]	



BOSCH

CP4.1 Cold Test R4 EU5 Audi [redacted]

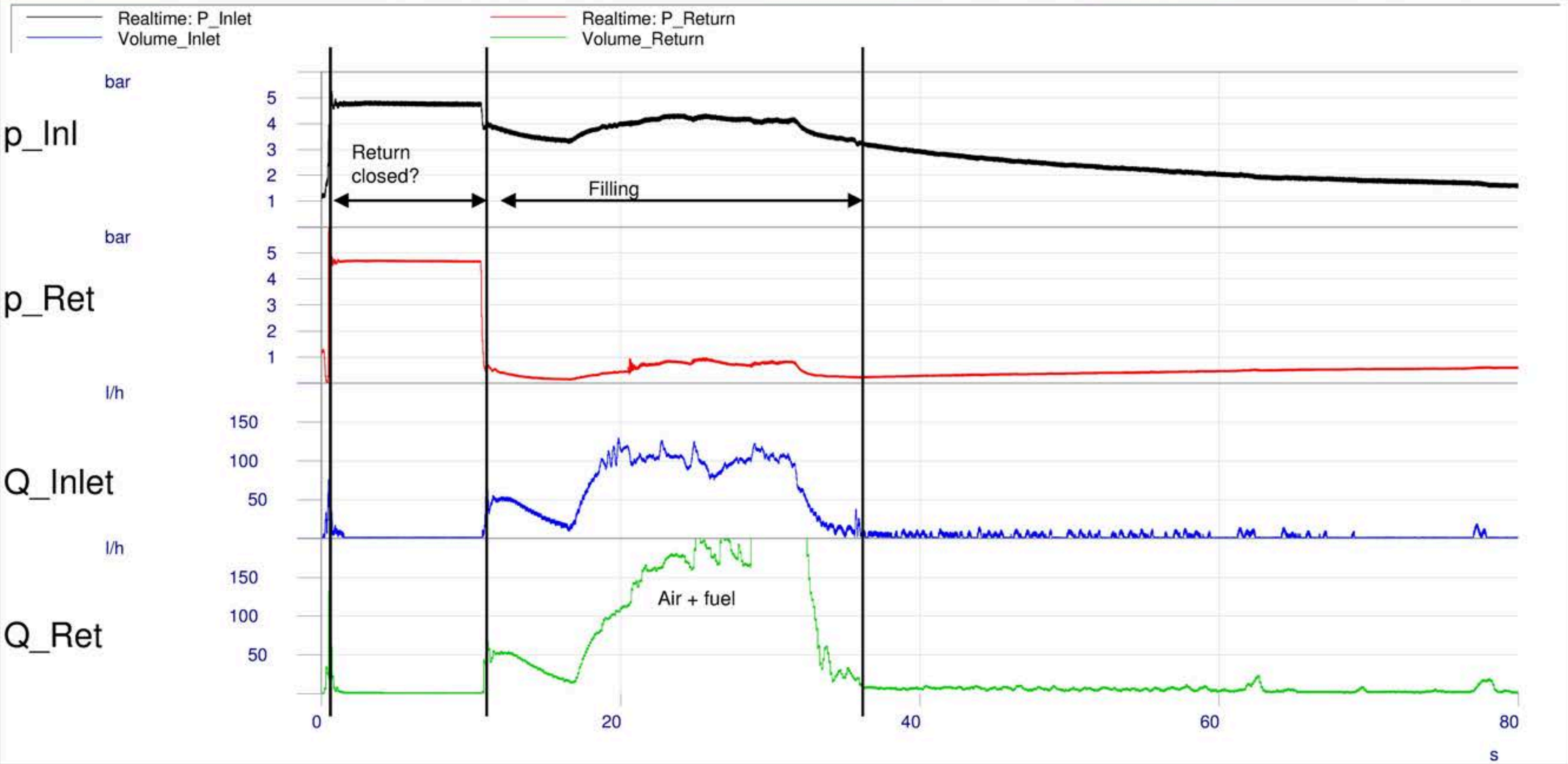
Measurement at filling station:

Measured values:
- p_Inlet
- p_Return
- Q_Inlet
- Q_Return

EA11003EN-00185[11]

CP4.1 Cold Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.8		nEngine	0	rpm		done by	[redacted]
Sample	Pump 04 100 408 BPT 0360		P_Rail	0	bar_rel		date	4/23/2008
testbench	Audi cold test bench no. 2 [redacted]		P_inlet	Approx. 4.0	bar			
	Filling station, pump before cold test		T_Inlet	20	°C		[redacted]	



BOSCH

CP4.1 Hot Test R4 EU5 Audi Non-responsive content removed

Task:

- Measure commissioning VW R4 TDI
- Measurements on the **hot test bench**

Trial execution:

- **Location:** Audi [redacted] hot test bench no.3
- **Pump assembly:** Series VW R4
- **Measured values:** Inlet and return pressure (Kistler sensors 10 cm before pump)
  engine speed with pickup on camshaft
  Rail pressure from engine RDS
  I_ZME, I_DRV with clamp meter measure
  Inlet and return volume with VSE

- **Measurement process:** Engine check program (engine fired)

- **Data recording:** LTT 186/16ch sampling rate 100 kHz

All results for pressure values in bar_rel !

CP4.1 Hot Test R4 EU5 Audi [redacted]

CP4

Results:

- Inlet volume, at 120-125 l/h, is below commissioning guidelines
- Process with correctly connected sensors OK
- Dragging with rail pressure 0 bar (PCV disconnected) without time limit > 1 min possible
- Test bench does not intervene automatically after 10 s dragging with rail pressure 0, intervention was always made by test bench staff

SUMMARY:

- Damage to a high-pressure fuel pump in hot test possible if PCV is disconnect-ed or has faulty contact
- Number of possibilities to repeat hot test after error occurs does not appear to be limited
- No change in test bench process found compared to measurements 1.5 years ago

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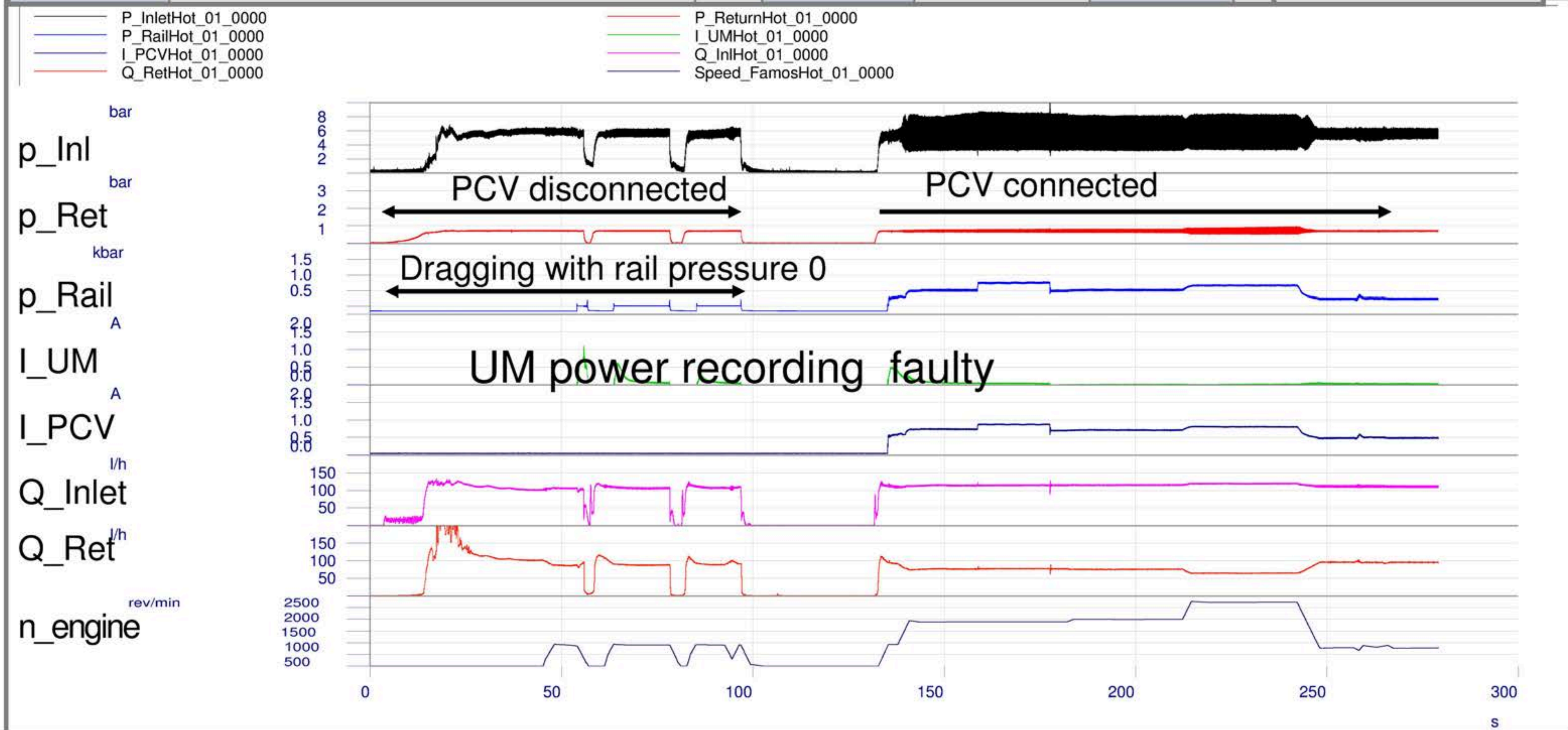
EA11003EN-00186[2]

CP4.1 Hot Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.95		n_{Engine}	var	rpm	done by	[redacted]
Sample	Pump 01 070 408 BPT 0620		P_Rail	var	bar_rel	date	4/23/2008
testbench	Audi hot test bench no. 3 [redacted]		P_inlet	Approx. 4.0	bar		
	Pump empty, hot test, 1st measurement		T_Inlet	20	°C	[redacted]	



Diesel Systems

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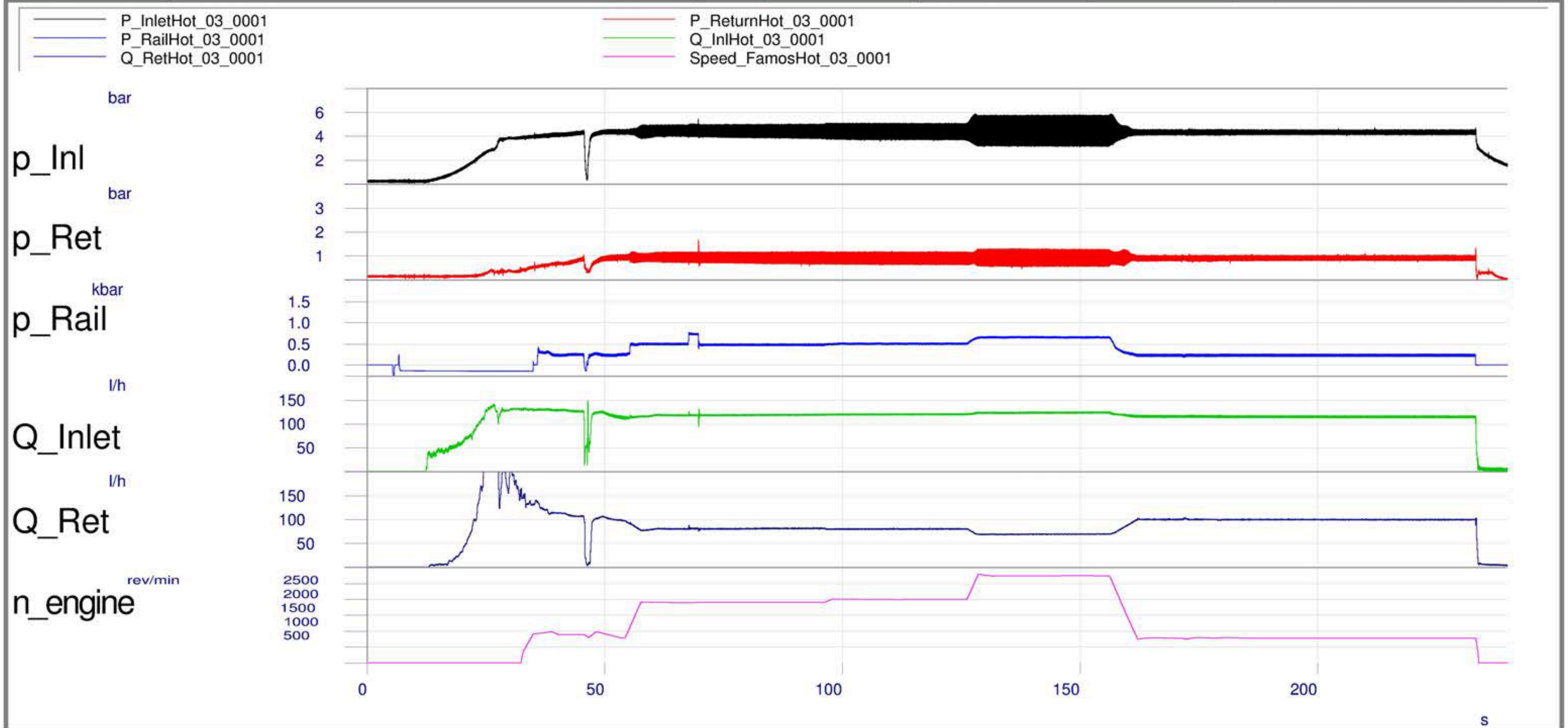
CP4.1 Hot Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.95		n_{Engine}	var	rpm		done by	[redacted]
Sample	Pump 01 070 408 BPT 0620		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi hot test bench no. 3[redacted]		P_inlet	Approx. 4.0	bar			
	Pump empty, hot test, 2nd measurement		T_Inlet	20	°C		Non-responsive content removed	



Diesel Systems

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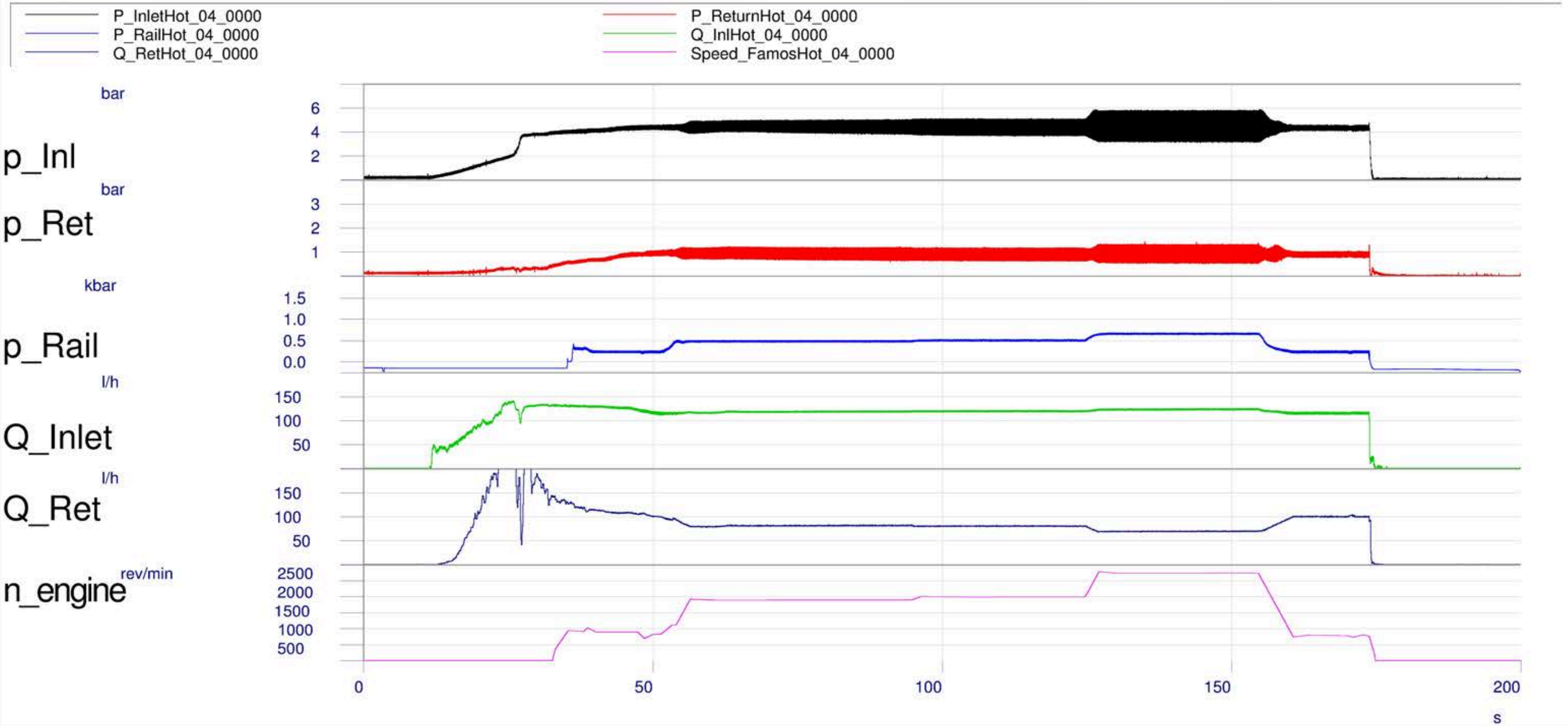
CP4.1 Hot Test R4 EU5 Audi [redacted]

CP4

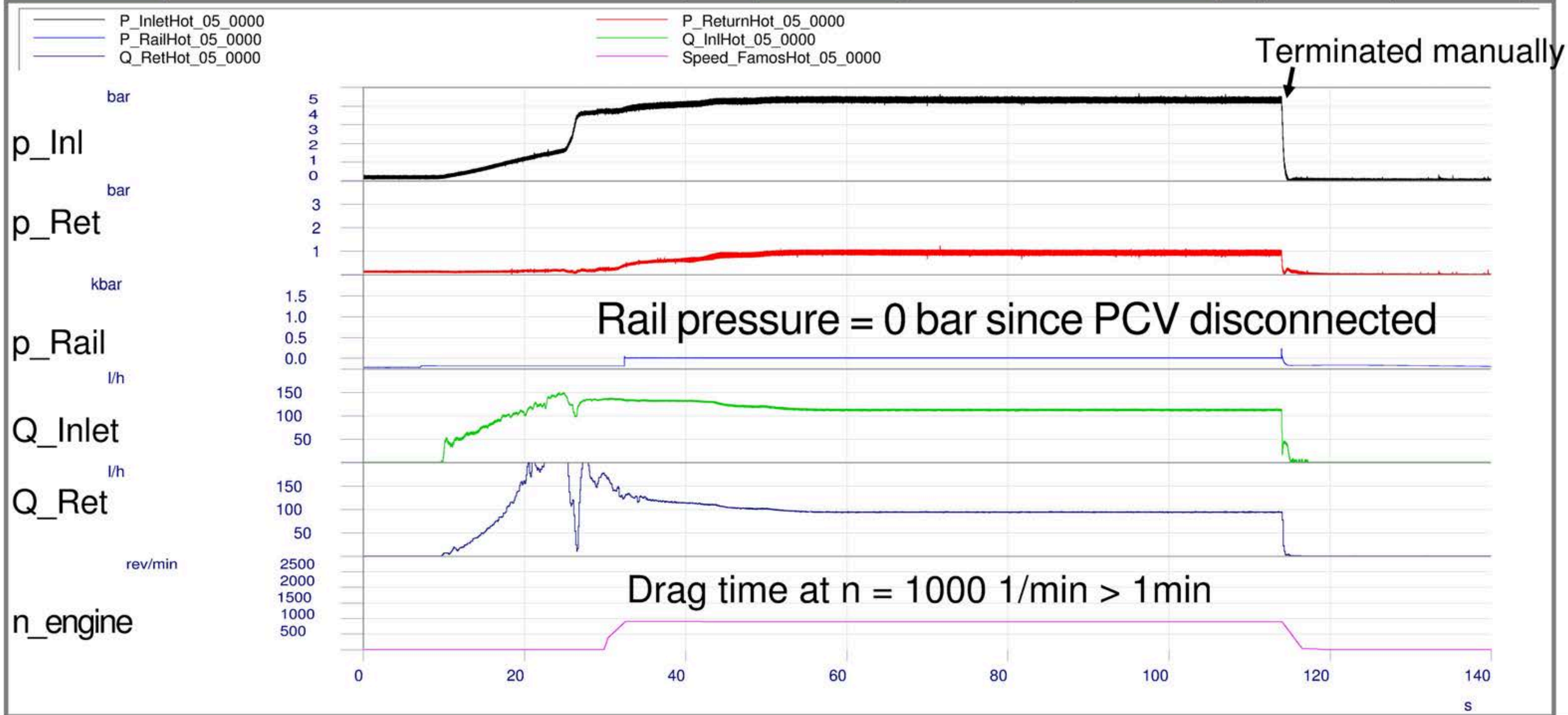
Pump	CP4.1_348_2x5.25_REC_3.3_1.95		n_{Engine}	var	rpm		done by	[redacted]
Sample	Pump 01 070 408 BPT 0620		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi hot test bench no. 3[redacted]		P_inlet	Approx. 4.0	bar			
	Pump empty, hot test, 3rd measurement		T_Inlet	20	°C		[redacted]	



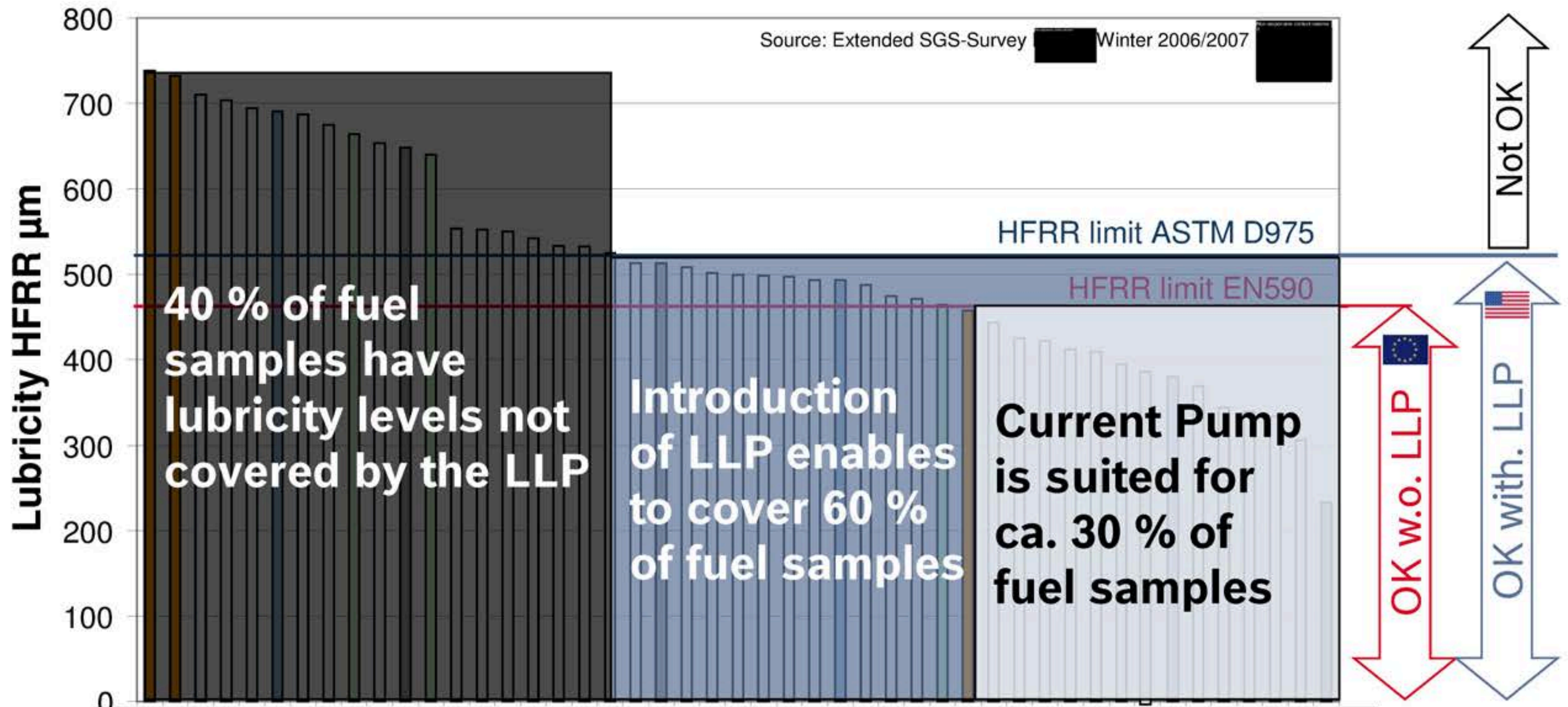
BOSCH

CP4.1 Hot Test R4 EU5 Audi Non-responsive content removed

Pump	CP4.1_348_2x5.25_REC_3.3_1.95		n_{Engine}	var	rpm		done by	[redacted]
Sample	Pump 01 070 408 BPT 0620		P_Rail	var	bar_rel		date	4/23/2008
testbench	Audi hot test bench no. 3 [redacted]		P_inlet	Approx. 4.0	bar			
	Hot test, PCV connector disconnected		T_Inlet	20	°C		Non-responsive content removed	



Relevance of LLP: Example of Non-responsive content removed [redacted]



Non-responsive content removed [redacted]

For RoW applications, LLP is a robustness improvement measure

CP4 robustness

Agenda

CP4 robustness

Main characteristics CP4 for car applications

Rail pressure	2000bar
Piston diameter / pitch	6.5mm / 6.75mm*
*New piston pitch stages: (6 / 6.5 / 7)mm	
Fuels	Without AWP: EN590
	with AWP: US fuels
Service life	300 000km
Fuel inlet temperature	70°C
Setpoint overflow valve	3.5 bar @ 50l/h

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CP4 robustness

Development main characteristics CP4 for MD & OHW

Rail pressure MD / OHW	**2500** / 2000bar
Piston diameter / pitch	6.5mm / **7.5**mm
Fuels	with AWP: US fuels
Service life MD / OHW	**750 000km** / 10 000h
Fuel inlet temperature	**80°C**
Setpoint overflow valve	3.5 bar @ 50 l/h

Development focus: Robustness of powertrain (P. 6)

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CP4 robustness

Powertrain damage mechanism (simplified cause-effect relationship)

How does powertrain damage occur?

Stiff roller -> Brake plates -> powertrain damage

Cause

μ_roller-roller support > μ_roller-camshaft

(target: μ_roller-camshaft >> μ_roller-roller support)

Why is μ_roller-roller support too high?

Manufacturing deviations, particularly elevations of the components (uneven rollers; roller support with metal spatters; faults confirmed in challenge experiments).

Manufacturing measures implemented & being implemented (P. 14).

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CP4 robustness

Why is μ_roller-roller support too high?

Insufficient lubricant layer height due to low-viscosity fuels with current component tolerances(contact of roughness peaks). Verification to kinematic viscosity 1.9mm2/s. Challenge experiments with components outside tolerance and overload do not show any striking features.

Note: Failures with fuel contaminated with 1% saltwater

Development measures* to increase robustness of CP4 from this cost-effect relationship (P. 6)

***Verification within CP4 MD & OHW platform trials**

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CP4 robustness

Development focus @ CP4 for MD & OHW

Increase robustness of powertrain (anti wear package)

1) Optimized roller surface

Parts of potential implemented by prohibiting installation of supplier 2 at Audi.

2) Optimized tappet assembly

Characteristic pressing & friction-optimized tappet implemented in W36 & W37; series implementation possible with customer approval. Other characteristics (tappet play, roller play) will be considered in the development of CP4 MD & OHW.

2) Optimized roller support surface/ in particular roller support coating

Parts of potential implemented for CP22/2 for W37 project.

4) Optimized cam

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CP4 robustness

Verification of approved fuels

without AWP: EN590

@ R.B. Verification with EN590

1) Kinematic viscosity:	2.5mm2/s
2) Lubricity:	460µm
3) Particles:	
4) Water:	200mg/kg

@ Customer: Verification in target market with country-typical fuel

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CP4 robustness

Verification of approved fuels
with AWP: ASTM 975-05 1D & 2D (US fuels with HFRR 520µm)

@ R.B. Verification with GDK570 (570µm)

1) Kinematic viscosity	1.9mm2/s
2) Lubricity	570µm (approved: 520µm)
3) Particles	
4) Water	500mg/kg

Random trials with GDK650, kerosene, gasoline, water, particles.

@ Customer: Verification in target market with country-typical fuel

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CP4 robustness

Approval for Rest of World (RoW) fuels

What does “Rest of World” fuels mean?

1) Kinematic viscosity	1.4mm2/s
2) Lubricity	570 µm
3) Particles	Fuel filter
4) Water	Water separator

Conclusions

- Platform verification needed
- Rise in cost of pump if use of anti wear package needed
- Approval only possible for specific fuel properties
- Thresholds for particles & water must be ensured by filters

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CP4 robustness

CR system robustness improvement with RoW fuels

- Increase inlet pressure level & coolant quantity through opt. EFP control
- Limit load if a “lower” temperature threshold is exceed
- Better filtration (particularly water) of inlet volume

Definition of requirement parameters for the system (such as vis-cosity, lubricity, water, particles, ...) needed to develop & insure the correct measures.

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CP4 robustness

CP4.2 failure statistics @ VW & Audi (from QMM3)

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CP4 robustness

CP4.1 failure statistics @ VW & Audi (from QMM3)

CP4 robustness

C4 failure statistics @ all customers (from QMM3)

CP4 robustness

Production measures (QMM3)

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Diesel Systems

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From	processor	Tel	Fax
[redacted]	Non-responsive content removed	Non-responsive content removed	Non-responsive content removed

[redacted]
2/15/2008
No. 882108

Log

Recipients Non-responsive content removed

For Info

Host Non-responsive content removed

Participants
Head
Log
Organiz.
Non-responsive content removed

Date/Location **02/13/2008, 3:00 – 6:30PM, [redacted], B12, mid. CfRm**

Topic **CP4 technical discussion (special subject: changes 2008)**

CP4 changes 2008

Bosch introduced the planned changes (design changes) in 2008 in the overview list and in detail.

During the introduction of the individual changes, the following procedure was agreed upon between Audi and Bosch:

1) C2.1 coated roller support + C2.1 coated roller crest:

=> with V6 W36/37, introduction FG 27.2.

2) Camshaft omission of bearing peen:

=> introduction with V8 Q7, V8 D4 and V6 W36/37; V6Bin5 not until wider trials, V12 after positive trial of V8

3) Spring seat, omission of anti-friction coating:

=> approval with V6 EU5 package B and transfer for V6 Bin5 and V12, decision for V6Bin5 after coordination with VW, clarify for V12 O Series Wk14 (Non-responsive content removed 02/15)

4) Standard calotte for cylinder head

=> Introduction for V6EU5, since introduction was positive for all other types; approved for V6 EU5 effective immediately

5) Piston head, omission of C2 layer:

=> Introduction for V6 Bin5 due to existing documents, decision by Audi after consultation with VW (02/15)

6) UM with NC bearing:

=> Trial with V6 EU5/CO2 package 3 (Wk9) and with V8 Q7, V8 D4, clarify for V12 O Series Wk14 (Non-responsive content removed, 02/15) ; System CR RB V12 already equipped, start Wk9; V6Bin5 conversion in series,

7) Roller short from second supplier Güntert

=> Approval will take place for V6 EU5 with package B in Wk36; approved immediately for V6 Bin5, verified in PTS and RB continuous running, ISIR for V12, series JhP for VW R4

As part of the meeting, we defined with Audi how the changes can be included in the

Diesel Systems

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From [redacted] processor [redacted] | Tel [redacted] | Fax [redacted]

[redacted]
02/15/2008
No. 882108

Log

CP4 technical discussion (special subject: changes 2008)

vehicle trials (see table).

Fahrzeugerprobungen	Änderungen	W26	W19BIN5 0-Serie KW10	W19BIN5 KW15	W19EU5 1800bar CO2 KW10	W19EU5 1800bar CO2 KW15
1. KW 10	ZME NC-Laber	ja*	ja	ja	ja	ja
Paket 3 (Design)	Entfall C-Schicht Kolbensonne	÷	nach Abspr. mit VW	ja	÷	÷
	Entfall Gleitlack Federteller	ja*	nach Abspr. mit VW	ja	ja	ja
2. KW15	wie Paket 3, zusätzlich					
Paket 4	Entfall Kugelstrahlen NM	Übernahme W24		ja	ja	ja
(Design + Kapa-Steigerungen)	Werksänderungen	Übernahme W24		ja		ja
Geplante Fahrzeugerprobungs-Stückzahl			50	20	10	10
Geplante Fahrzeugerprobungs-Stückzahl [redacted]			50**	15+5	5+5	5+5

Table texts:
(Design + Kapa-Steigerungen) = (design + cap. increase)
2. KW15 = 2. Wk15
Änderungen =Changes
Entfall C-Schicht Kolbensonne= Omission of C layer piston head
Entfall Gleitlack Federteller = Omission of anti-friction coating on spring seat
Entfall Kugelstrahlen NM = Omission of bearing peen
Fahrzeugerprobungen = Vehicle trials
Geplante Fahrzeugerprobungs-Stückzahl ([redacted] =Planned vehicle trial units [redacted]

Geplante Fahrzeugerprobungs-Stückzahl = Planned vehicle trial units
ja = Yes
KW = Wk
nach Absprache mit = after discussion with VW
Paket 3 (Design) = Package 3 (Design)
Paket 4 = package 4
Serie = Series
Übernahme W42 = Transfer W24
Werksänderungen = Plant changes
wie Paket 3, zusätzlich = Like package 3, plus
ZME NC-Laber = ZM NC-Laber

* All from Wk14, check O Series
** Preproduction from Wk10, only for [redacted]

[redacted]

With regard to the changes omission of C layer from piston head and omission of anti-friction coating on spring seat, Audi would like to discuss the situation with VW. A decision is planned by the end of Wk07.

[redacted]

Agenda:

CP4 changes 2008

Version overview / subject overview

trial Overview

CP4 technical discussion Audi 02/13/2008

Customer	Project	Pump	Pressure	Pitch	FP	Cold package	AWP	Approval no. or pattern no.	Batch	Start DL or delivery date	Outlook Roller support C2.1 or C3 opt. instead of C3	Roller: Cone C2.1 layer	Camshaft: Omission of bearing peen, with 1-stage Finnish	spring seat: Omission of anti-friction coating	Cylinder head Standard calotte red. Play (Pressure compensation ridge)	Cylinder head: Piston head w/o C2 (only AWP)	UM: with NC warehouse	Roller: Second supplier Güntert, Short version	Duplication of tools due to capacity increase, Details: see change package A+B	Duplication of tools due to capacity increase, Details: see change package 4
Audi	V6 EU5/CO2							Series with index	Change package 3, 10 units	Wk10	-	-	x	x	x		x	x	-	-
Audi	V6 EU5/CO2							Series with index	Change package 4, 10 units	Wk15	-	-	x	x	x		x	x	-	x
Audi	V6 Bin5/EU6							Series with index	Change package 3, 50 units	Wk10	-	-	-	?	x	?	x	x	-	-
Audi	V6 Bin5/EU6							Series with index	Change package 4, 40 units	Wk15	-	-	x	x	x	?	x	x	-	x
Audi	V12							Series with index	Change package 3+4, O series	Wk14?	-	-	-	x	x		x	x	-	?
Audi	V6 EU5/CO2	CP4.2	1800	4.85	EFP	No	No	0 445 010 611	Target state of series		x	x	x	x	x		x	x	x	x
Audi	V6 EU5/CO2							Series with index	Change package 1		-	-	-	-	-		-	-	-	-
Audi	V6 EU5/CO2							Series with index	Change package B, 10 units	Wk06	-	-	-	x	-		-	x	x	-
Audi	V6 EU6/Bin5	CP4.2	2000	5.6	EFP	FP1	Yes	0 445 010 613	Target state of series		x	x	x	x	x	x	x	x	x	x
Audi	V6 EU6/Bin5							0 445 B20 169_09	Comp. CR, 6x2000h	Running	-	-	-	-	-	-	-	x	-	-
Audi	V6 EU6/Bin5							0 445 B20 169_11a	Syst. CR, 2x2000h	A.2008	-	-	-	x	x	x	x	x	-	-
Audi	V6 EU6/Bin5							Series no. with index	D sample (ISIR)	Wk48	-	-	-	-	x	-	-	-	-	-
Audi	V6 EU6/Bin5							Series no. with index	D sample	(A.2008)	-	-	-	?	x	?	x	x	-	-
Audi	V12	CP4.2	2000	5.6	ZP38	FP1	No	0 445 010 619	Target state of series		x	x	x	x	x		x	x	x	x
Audi	V12							0 445 B20 200_03	Comp. CR, 2x2000h	Completed	-	-	-	-	x		-	x	-	-
Audi	V12							0 445 B20 200_04a	Syst. CR, 2x2000h	A.2008	-	-	-	x	x		x	x	-	-
Audi	V12							Series with index	D sample (ISIR)	Wk 04	-	-	-	-	x		-	x	-	-
Audi	V12							Series with index	D sample	(A.2008)	-	-	-	x	x		x	x	-	-
Audi	V8 Q7	CP4.2	2000	5.6	ZP38	FP1	No	0 445 010 620	Target state of series		x	x	x	x	x		x	x	x	x
Audi	V8 Q7							0 445 B20 172_06	Comp. CR, 4x2000h	Completed	-	-	-	x	x		-	x	-	-
Audi	V8 Q7							0 445 B20 172_08	Syst. CR, 2x2000h	A.2008	-	-	x	x	x		x	x	-	-
Audi	V8 Q7							0 445 B20 172_09	C sample	Wk13	-	-	x	x	x		x	x	-	-
Audi	V8 Q7							To be determined	D sample	Wk20	-	-	x	x	x		x	x	-	-
Audi	V8 D4	CP4.2	2000	5.6	EFP	FP1	No	To be determined	Target state of series		x	x	x	x	x		x	x	x	x
Audi	V8 D4							0 445 B20 188_03a	Comp. CR, 2x2000h	A.2008	-	-	x	x	x		x	x	-	-
Audi	V8 D4							0 445 B20 188_04	Syst. CR, 2x2000h	A.2008	-	-	x	x	x		x	x	-	-
Audi	V8 D4							0 445 B20 188_06	Syst. CR, 2x2000h	A.2008	-	x	x	x	x		x	x	-	-
Audi	V8 D4							0 445 B20 188_07	C sample	Wk04	-	-	x	x	x		x	x	-	-
Audi	V8 D4							0 445 B20 188_05	C sample	Wk05/08	-	-	x	x	x		x	x	-	-
Audi	V8 D4							To be determined	D sample	M.2008	-	-	x	x	x		x	x	-	-
Audi	V6 W36/37	2000 6			EFP FP1		No	To be determined	Target state of series		x	x	x	x	x		x	x	x	x
Audi V6	W36/W37							0 445 B20 220_01	B sample	A.2008	(x)	(x)	x	x	x		x	x	-	-

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CP4 technical discussion Audi 02/13/2008

Suggestion for how to proceed:

1) C2.1 coated roller support + C2.1 coated roller crest:

=> with V6 W36/37, introduction FG 27.2.

2) Camshaft omission of bearing peen:

=> introduction with V8 Q7, V8 D4 and V6 W36/37; V6Bin5 not until wider trials, V12 after positive trial of V8

3) Spring seat, omission of anti-friction coating:

=> approval with V6 EU5 package B and transfer for V6 Bin5 and V12, decision for V6Bin5 after consultation with VW, clarify for V12 O Series Wk14 ([redacted], 02/15)

4) Standard calotte for cylinder head

=> Introduction for V6EU5, since introduction was positive for all other types; approved for V6 EU5 effective immediately

5) Piston head, omission of C2 layer:

=> Introduction for V6 Bin5 due to existing documents, decision by Audi after consultation with VW (02/15)

6) UM with NC bearing:

=> Trial with V6 EU5/CO2 package 3 (Wk9) and with V8 Q7, V8 D4, clarify for V12 O Series Wk14 ([redacted], [redacted], 02/15) ; System CR RB V12 already equipped, start Wk9; V6Bin5 conversion in series,

7) Roller short from second supplier Güntert

=> Approval will take place for V6 EU5 with package B in Wk36; approved immediately for V6 Bin5, verified in PTS and RB continuous running, ISIR for V12, series JhP for VW R4

CP4 technical discussion Audi 02/13/2008

Current version overview

	Audi V6 EU5 / CO2	Audi V6 EU6/Bin5	Audi V6 W36/W37	Audi V8 EU5/ D4	Audi V8 EU5/ Q7	Audi V12 EU5	VW R4 EU5	VW R4 Bin5
Type Part No.	… 611	… 613	B sample	C sample	… 620	… 619	… 507	
Design	CP4.2 CP4.2	H	CP4.2H	CP4.2H	CP4.2H	CP4.2H	CP4.1	CP4.1
Presupply	EFP	EFP	EFP	EFP	ZP38	ZP38	EFP	EFP
Pressure	1800	2000	1800/2000	2000	2000	2000	1800	1800
Ratio	3/4	3/4	3/4	1	1	3/4	1	1
Rotation direction	Right	Right	Right	Left	Left	Left	Right	Right
n(Pp/Mot) Pmax.	3750(5000)	3750(5000)	3750(5000)	4500	4500	3750(5000)	4500	4500 **)
n(Pp/Mot) Pmin.	4125(5500)	4125(5500)	4125(5500)	5000	5000	4125(5500)	5300	5300 **)
n(Pp/Mot) over	4315(5750)	4315(5750)	4315(5750)	5250	5250	4315(5750)	5500	5500 **)
Cam pitch	4.85	5.6	**6**	5.6	5.6	5.6	5.25	5.25
AWP	No	AWP1 *)	No	No	No	No	No	AWP1
Shaft seal	Kaco	Bruss / KP1	Bruss / KP1	Bruss / KP1	Bruss / KP1	Bruss / KP1	Bruss / KP1	Bruss / KP1
Cylinder head	1x front, 1x back	1x front, 1x back	2x back	2x front	2x front	2x back	1x back	1x back
Drive	Long shaft, 1WDF	Long shaft, 1WDF	Long shaft, 2WDF	Long shaft, 1WDF	Long shaft, 1WDF	Long shaft, 2WDF	Short shaft, 1WDR	Short shaft, 1WDR
Quantity balance	**OK**	**OK**	**OK**	**Critical**	**Critical**	**OK**	**OK**	**OK**

Open items:

- Commissioning guideline: V6 OK, R4 still open, meeting RB Fröhlich on 01/30
- Bearing strength measurement V6Bin5: Values currently too high, RB open to new measurement with changed config.
- Determination V6 W36/37: Space for bolt indent being clarified

*) Warm up with AWP1, omission of AWP1 for EU version planned in PKO measure

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EA11003EN-00262[illegible]

CP4 technical discussion Audi 02/13/200

RB components trial CR (1800/2000bar, US fuel GDK 570, EFP version)

Type	PNR	Vers.	Pump. No.	M status	WDR	cold seal	Pitch	CR progr.					10/01	10/08	10/15	11/12	11/19	11/26	12/03	12/10	12/17		01/07	01/14	01/21	01/28	02/04	02/11	
PF CP4.1S 1800bar, US fuel	063_02	AWP1	686-4106	B1 (C2)	KACO	-	6	PDL_2000	2000	CR passed																			
	063_02	AWP1	686-4107	B1 (C2)	KACO	-	6	PDL_2000	2000	CR passed																			
	060_08	No AWP	690-4592	B1 (C2)	KACO	-	5.25	PDL_2000	2000	CR passed																			
	060_08	No AWP	690-4594	B1 (C2)	KACO	-	5.25	PDL_2000	2000	CR passed																			
CP4.1S 1800bar, US-Fuel, EE customer **VW R4 Bin5**	060_12	AWP1	200207-0040	C2	Bruss	-40°C OK	5.25	PDL_2000	2001	CR passed																			
	060_12	AWP1	200207-0041	C2	Bruss	-40°C OK	5.25	PDL_2000	2001	CR passed																			
	060_12	AWP1	200207-0042	C2	Bruss	-40°C OK	5.25	PDL_2000					1905	2000	CR passed														
	060_12	AWP1	200207-0043	C2	Bruss	-40°C OK	5.25	PDL_2000	2000	CR passed																			
	060_12	AWP1	200207-0044	C2	Bruss	-40°C OK	5.25	KDL_500	500	CR passed																			
	060_12	AWP1	200207-0048	C2	Bruss	-40°C OK	5.25	KDL_500	500	CR passed with restrictions Flange bearing fused																			
	060_12	AWP1	200207-0049	C2	Bruss	-	5.25	KDL_500	549	CR passed																			
PF CP4.2HS, 2000bar, US fuel	154_07	AWP1	690-4589	B2 (C2)	KACO	-	6	PDL_2000	2000	CR passed																			
	154_07	AWP1	690-4590	B2 (C2)	KACO	-	6	PDL_2000	2000	CR passed																			
	154_10	AWP1	781-4837	B2 (C2)	Bruss	-40°C OK	6	PDL_2000	2000	CR passed																			
	154_10	AWP1	781-4838	B2 (C2)	Bruss	-40°C OK	6	PDL_2000	2000	CR passed																			
CP4.2HS, 2000bar, US fuel EE customer	169_08	AWP1	783-4680	C2	Bruss	-40°C OK	5.6	PDL_2000	2000	CR not passed Lateral roller warm-up; UM diag. OK																			
	169_08	AWP1	783-4681	C2	Bruss	-40°C OK	5.6	PDL_2000	2000	CR not passed Lateral roller warm-up; UM diag. OK																			
	169_09	AWP1	785-4263	C2	Bruss	-40°C OK (2000h)	5.6	PDL_2700										9	1886	1975	2000	Interim diagnosis 2000h OK					Projected further run 02/15/2008		
	169_09	AWP1	785-4264	C2	Bruss	-40°C OK (2000h)	5.6	PDL_2700					610	650	779	1384	1551	1719	1886	1975	2000	Interim diagnosis 2000h not OK MU O ring sheared off							
	169_08	AWP1	783-4678	C2	Bruss	-40°C OK	5.6	KDL_500	500	CR passed																			
	169_08	AWP1	783-4679	C2	Bruss	-40°C OK	5.6	KDL_500	500	CR passed																			
	169_09	AWP1	785-4268	C2	Bruss	To be planned	5.6	PDL_2000																1153	1222	1388	1555	1720	
	169_09	AWP1	786-4533	C2	Bruss	To be planned	5.6	PDL_2000																1153	1157	ZWM	ZWM	ZWM	

Continue run to 2700h

Repeat attempt due to lateral roller warm-up

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CP4 technical discussion Audi 02/13/2008

RB component trial CR (1800/2000bar, EN590, CP version)

	Nec. CR to achieve B10 target									Date													
	PNR	Pump no.	E status	Pitch	CR progr.	WDR	cold seal	CP diagnosis			08/06	08/13	08/20	08/27	3.09	09/10	09/17	10/01	10/08	10/15	11/12	11/19	
Platform CP4.1S 1800bar, ACP, 4500rpm	045_01	685-4778	B0.2	6	KDL_1000	KACO	-	OK	1000	**CR passed**													
	045_01	685-4777	B0.2	6	KDL_1000	KACO	-	OK	1000	**CR passed**													
	045_01	685-4996	B0.2	6	PDL_2000	KACO	-	OK	2000	**CR passed**													
	045_01	685-4780	B0.2	6	PDL_2000	KACO	-	OK	2000	**CR passed**													
	045_01	685-4776	B0.2	6	PDL_2000	KACO	-	OK	2000	**CR passed**													
	045_01	685-4931	B0.2	6	PDL_2000	KACO	-	OK	2000	**CR passed**													
Platform CP4.2S 1800bar, ACP, 3750rpm	131_03	685-4944	B0.2	6	KDL_1000	KACO	-	OK	1000	**CR passed**													
	131_03	685-4938	B0.2	6	PDL_2000	KACO	-	CP-WDR med. wear	2000	**CR passed with restrictions** NW: Wear through ACP-WDR, fretting of SV seal													
	131_03	685-4939	B0.2	6	PDL_2000	KACO	-	CP-WDR med. wear	2000	**CR passed with restrictions** NW: Wear through ACP-WDR, fretting of SV seal													
	131_03	685-4942	B0.2	6	KDL_1000	KACO	-	OK	1000	**CR passed**													
	131_03	685-4945	B0.2	6	PDL_2000	KACO	-	CP-WDR med. wear	2000	**CR passed**													
	131_03	685-4947	B0.2	6	PDL_2000	KACO	-	CP-WDR med. wear	2000	**CR passed**													
	170_01	691-4855	B1	6	PDL_2000	KACO	-25°C R4	OK	2001	**CR passed**													
	170_01	691-4859	B1	6	PDL_2000	KACO	-25°C R4	OK	2001	**CR passed with restrictions** due to fused flange bearing													
EE customer (V12) CP4.2HS, 2000bar ACP, 3750rpm	200_03	785-4202	C	5,6	PDL_2000	BRUSS	-40°C R1	**Function OK** Clutch piece embedded in CP cover			749	913	1079	1172	1336	1503	1668	1966	2000	**CR passed** UM diagnosis OK			
	200_03	785-4203	C	5,6	PDL_2000	BRUSS	-40°C R1	**Function OK** Clutch piece embedded in CP cover			749	913	1079	1172	1336	1503	1668	1966	2000	**CR passed** UM diagnosis OK			
EE customer (V8) CP4.2HS, 2000bar ACP, 4500rpm	172_06	785-4254	C	5,6	PDL_2000	BRUSS	-40°C R1	**Function OK** Clutch piece embedded in CP cover			0	26	130	288	360	490	654	981	1148	...	1950	2000	**CR passed**
	172_06	785-4255	C	5,6	PDL_2000	BRUSS	-40°C R1	**Function OK** Clutch piece embedded in CP cover			0	26	130	288	360	490	654	981	1148	...	1950	2000	**CR passed with restrictions** due to tear in UM strainer
	172_06	785-4256	C	5,6	PDL_2000	BRUSS	-	**Function OK** Clutch piece embedded in CP cover			Redesign spring plate w/o anti-friction coating			...	286	446	614	919	1086	...	1920	2000	**CR passed**
	172_06	785-4257	C	5,6	PDL_2000	BRUSS	-	**Function OK** Clutch piece embedded in CP cover						...	286	446	614	919	1086	...	1920	2000	**CR passed**
	172_06	785-4258	C	5,6	KDL_500	BRUSS	-	**Function OK** Clutch piece embedded in CP cover						...	398	500	**CR passed**						
	172_06	785-4259	C	5,6	KDL_500	BRUSS	-	**Function OK** Clutch piece embedded in CP cover						...	398	500	**CR passed**						

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CP4 technical discussion Audi 02/13/2008

RB component trial CR (2000bar, EN590, EFP version)

	PNR	Pump no.	E status	WDR	cold seal	Pitch	CR progr.	Nec. CR to achieve B10 target		10/01	10/08	10/15	10/22	10/29	...	...	02/04	02/11	02/18	02/25	03/03	03/10	03/17	03/24	
Platform CP4.1H, 2000bar, EFP, EN590, 4800rpm	051_09	686-01-125	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
	051_09	686-01-126	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
	051_09	686-0127	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
	051_09	686-0128	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
CP4.1HS EE customer, 4800rpm	050_07	690-01-4599	C2H	KACO	-25°C OK	5,25	PDL_2000	2000	CR Passed																
	050_07	690-01-4601	C2H	KACO	-25°C OK	5,25	PDL_2000	2000	CR passed																
	050_07	690-01-4603	C2H	KACO	-	5,25	KDL_500	500	CR passed																
	050_07	690-01-4605	C2H	KACO	-	5,25	KDL_500	500	CR passed																
Platform CP4.2H, 2000bar, EFP, EN590, 3750rpm	133_15	689-4810	B2H (C2)	KACO	-	6	KDL_500	500	CR passed																
	133_15	689-4811	B2H (C2)	KACO	-	6	KDL_500	500	CR passed																
	133_15	687-0243	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
	133_15	687-0244	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
	133_15	689-4808	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed with restriction WDR in CR leaking, rating 3 (WDR wet)																
	133_15	689-4809	B2H (C2)	KACO	-	6	PDL_2000	2000	CR passed																
CP4.2HS EE customer, 3375rpm	155_06	783-4349	C2	KACO	-	5,25	PDL_2000			2000	CR passed														
	155_06	783-4350	C2	KACO	-	5,25	PDL_2000			2000	CR passed														
CP4.2HS EE customer 4500rpm	188_03	789-4266	C2	BRUSS	To be planned	5,6	PDL_2000									Redesign	TW	0							
	188_03	789-4267	C2	BRUSS	To be planned	5,6	PDL_2000									Redesign	TW	0							

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CP4 technical discussion Audi 02/13/2008

RB system trial CR (Audi, VW)

Type	PNR	Pump.No.	Sample	WDR	cold seal.	Pitch	CR progr.		10/22	10/29	11/05	11/12	11/19	11/26	12/03	12/10	12/17		01/07	01/14	01/21	01/28	02/04	02/11	
CP4.1S 1800bar, US fuel **VW R4 Bin5**	508	020507-0313	C	Bruss		5,25	PDL_2000		233	387	453	600	750	855	997	1113	1250	...	1530	ZWM	ZWM	1654	1818	1948	
	060	130407-0311	C	Bruss		5,25	PDL_2000		233	387	453	600	750	855	997	1113	1250	...	1530	ZWM	ZWM	1654	1818	1948	
	060	270407-0001	C	Bruss		5,25	PDL_2000		731	895	1038	1188	1331	1497	1657	1801	1993	...	**2020**	**CR ended**					
	060	250407-0346	C	Bruss		5,25	PDL_2000		731	895	1038	1188	1331	1497	1657	1801	1993	...	**2020**	**CR ended**					
CP4.2HS 2000bar, US fuel **Audi V6 BIN5**	169_11	788-4959	C	Bruss		5,6	PDL_2000								13	13	13	...	389	ZWM	461	621	692	837	
	169_11	788-4960	C	Bruss		5,6	PDL_2000								13	13	13	...	389	ZWM	461	621	692	837	
	169_11	787-4938	C	Bruss		5,6	PDL_2000									**Redesign** Piston head w/o C layer UM with NC bearing spring plate w/o AFC							65	197	
	169_11	787-4939	C	Bruss		5,6	PDL_2000																65	197	
CP4.2HS 2000bar, EN590 **Audi V6 EU6**	169_11	787-4940	C	Bruss		5,6	PDL_2000									**Redesign** Piston head w/o C layer UM w/ NC bearing spring plate w/o AFC				7	21	141	271	379	
	169_11	787-4941	C	Bruss		5,6	PDL_2000													7	21	141	271	379	
CP4.2HS 2000bar, EN590 **Audi V12 EU5**	200_04	787-4727	C	Bruss		5,6	PDL_2000								92	255	420	...	852	1011	1011	1266	1432	1504	
	200_04	787-4728	C	Bruss		5,6	PDL_2000								113	287	399	...	827	952	999	1151	1314	1506	
	200_04	787-4730	C	Bruss		5,6	PDL_2000									**Redesign** 2-stage OV with recess UM w/NC bearing ger							**Commissioning planned for Wk09/2008 End prep. Wk34/2008**		
	200_04	787-4731	C	Bruss		5,6	PDL_2000																		
CP4.2HS 2000bar, EN590 **Audi V8 EU5 ZP**			C	Bruss		5,6	PDL_2000																**Commissioning planned for Wk12/2008 End prep. Wk37/2008**		
			C	Bruss		5,6	PDL_2000																		
CP4.2HS 2000bar, EN590 **Audi V8 EU5 EFP**			C	Bruss		5,6	PDL_2000																**Commissioning planned for Wk14/2008 End prep. Wk39/2008**		
			C	Bruss		5,6	PDL_2000																		
			C	Bruss		5,6	PDL_2000																**Commissioning planned for Wk36/2008 End prep. Wk51/2008**		
			C	Bruss		5,6	PDL_2000																		

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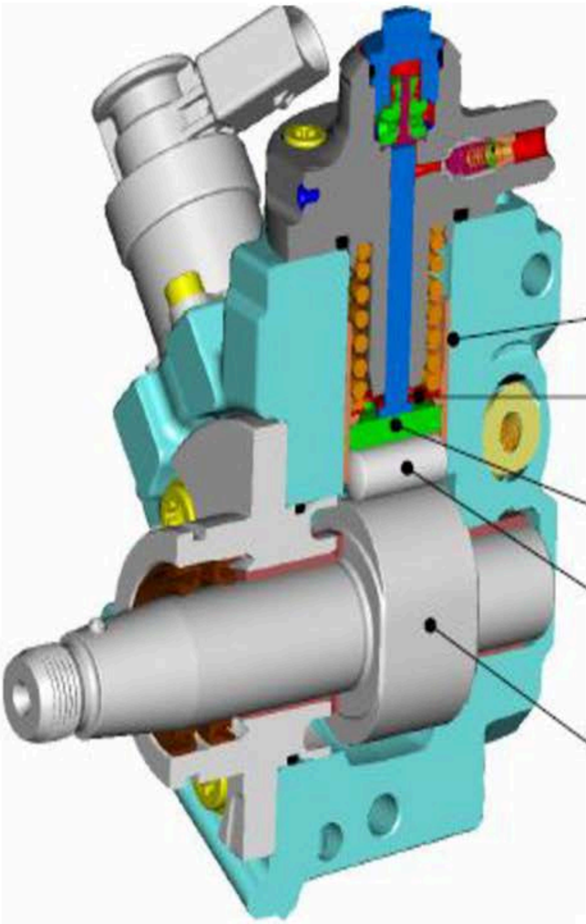
						Additional pumps	
<u>Endurance run pumps f. Audi</u>			W26	BIN5 0-series WK10	BIN5 Further dev. WK15	EU5 1800 bar CO2 KW15	EU5 CO2 WK15
1. WK 10 Packet 3	Pcs.	• Metering unit nc-bearing	Yes	Yes	Yes	Yes	Yes
			--	After verification VW	Yes	--	--
		• No C-layer piston sensor	Yes	After verification VW	Yes	Yes	Yes
2. WK 15 (?) Packet 4		• " Bonded coating of spring seat	Takeover W24	Yes	Yes	Yes	Yes
	+ factory changes:	As packet 3, plus: • No camshaft shotpeening	-" -		Yes		Yes
		-----------------------------------> Piece count		50	20	10	10
			All from WK14 Check 0-series	50 Preliminary series	15 + 5 EK/[redacted] from WK10 [redacted]	5 + 5	5 + 5

EA11003EN-00276[0]



EA11003EN-00276[1]

Safety considerations for turned tappet CP4.1

CP4

Analytical consideration for turned tappet

Safety = loading capability / loading

Loading capability =
Aligning and locking torques about the longitudinal tappet axis

Loading =
Exciting torques about the longitudinal tappet axis

Safety considerations for turned tappet CP4.1

Influencing variables + loading capability boundary conditions

1. Cam lead

   Axial force, roller length, local angle of application of force on cam

2. Tappet spring torsion

   Torsional rigidity of spring, "exciting" turn angle, limited by spring friction at contact surfaces:

   Friction coefficient spring seat + axial spring force

3. Friction between housing and tappet in the circumferential direction

   Tappet diameter, friction coefficient of tappet housing (circumference), medium angular velocity, transverse force on tappet

4. Fluid friction

   Tappet diameter, length, diametral clearance, dynamic viscosity, angular velocity

5. Inertia

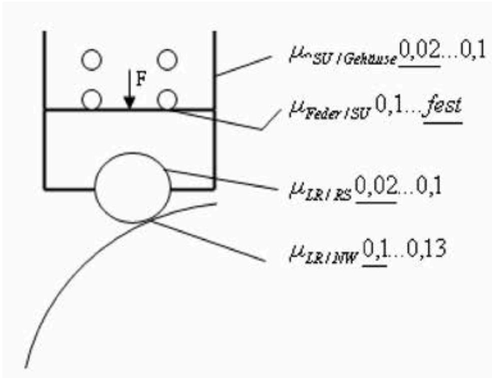
   Angular acceleration, moment of inertia of tappet assembly

EA11003EN-00276[3]

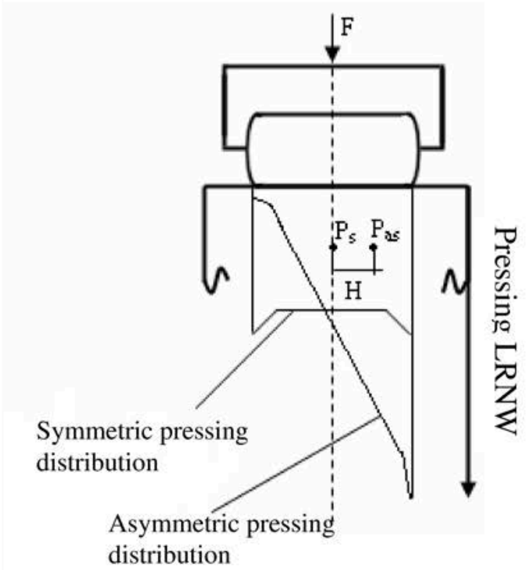
Safety considerations for turned tappet CP4.1

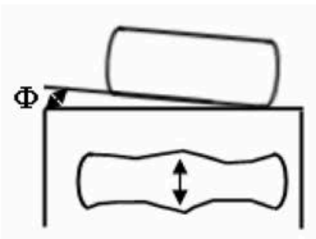
Considered influencing variables

4 frictional contacts:



Asymmetric surface presses





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EA11003EN-00276[4]

Safety considerations for turned tappet CP4.1

Safety in all four cases:

	Direction of stroke	Cam and angle	Camshaft first	Load status FM	Remark	Safety
1 Case	Ascending	45	Unity NoWe	Maximum delivery		53.4
2 Case	Ascending	45	Unity NoWe	Zero delivery		6.7
3 Case a	Ascending	45	Unity NoWe	not relevant (suction)	Spring not broken in	3.5
3 Case b	Ascending	45	Unity NoWe	not relevant (suction)	Spring broken in	34.5

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EA11003EN-00276[5]

Safety considerations for turned tappet CP4.1

CP4

Further work:

- **Parameterization**

  Safety considerations for all cam angles

- **Compare boundary conditions with actual measurements and explain for different operating conditions**

EA11003EN-00276[6]

Overview of functional test measurements turned tappet CP4.1

Task:

- Measurement of the tappet movement about the vertical axis
- Inclusion of different operating conditions and available part types

Test execution:

- **Pump:** CP4.1-348_2x5.25 ZP sand casting housing adapted to EFP
- **Pump fitting:** on pump test bench
- **Readings:**
  - Relative rotation of the tappet body in operation, no zero-measurand output
  - Axial path of the camshaft
  - Rail pressure, pump speed, ZME current
- **Test sequences:**
  - Factory test sequence as in pump manufacturing
  - Development test sequence DS/EHP2
  - Speed ramps 0-1000 rpm with minimum rail pressure
- **Parameter variation:**
  - See following slides
  - Only one parameter was changed per test!

EA11003EN-00276[7]

Overview of functional test measurements turned tappet CP4.1

Overview of influences investigated:
1. Operating conditions:

Influence	Operating conditions	Effect on turned tappet	Picture
Engine speed	Starting the pump	Highest turned tappet values reached when the pump starts before alignment via engine speed -Increasing engine speed: Turned tappet is less	Page 11
	>3000 rpm	During first start-up at the factory: Alignment of tappet combination using engine speed level 3,375 rpm	
	Stopping the pump (overrun condition)	No critical increase in the turned tappet when decreasing the speed to 0	
Rail pressure	Starting the pump	After build-up of the minimum rail pressure reduction of the turned tappet	
	Operation	Tendency: Rail pressure is higher, lower turned tappet	
Filling (I-ZME)	Start + operation	No detectable influence	
Inlet pressure	Start	Even with incomplete venting, no impact No effect on start-up without inlet pressure	
	Operation	No influence in the context of the conditions tested	
Back pressure	Start + operation	No detectable influence	

EA11003EN-00276[8]

Overview of functional test measurements turned tappet CP4.1

Overview of influences investigated:
2. Component influences of tappet assembly:

Component	Parameter variation	Effect on turned tappet	Picture
Direction of spring coiling	right	Basic case series	
	left	No effect, the direction of turn LS depends on the spring turn direction	Page 12
Roll	Roll stuck	extreme turned tappets till 30°	Page 13
Roll length	24.9 mm)	not rated yet	
	24.7 mm)	Similar to the series case, basic case also included in all measurements	
	24.5 mm)	not rated yet	

Overview of functional test measurements turned tappet CP4.1

Overview of influences investigated:
3. Component influences of camshaft / housing

Component	Parameter variation		Picture
Camshaft axial clearance	0.17 mm	Basic case of the metering pump CP4.1	
	0.27 mm	Slight advantages compared to 0.03 mm	
	0.03 mm	see above	
Cam stroke	5.25 mm	The basic case	
	6 mm	No difference from 5.25 mm stroke (in inspections with CP4.2)	
Cylinder head assembly	Wear of screw travel in ZK	No impact of turning the ZK within the screw travel detected following the alignment run. Travel is about ± 1°	

EA11003EN-00276[10]

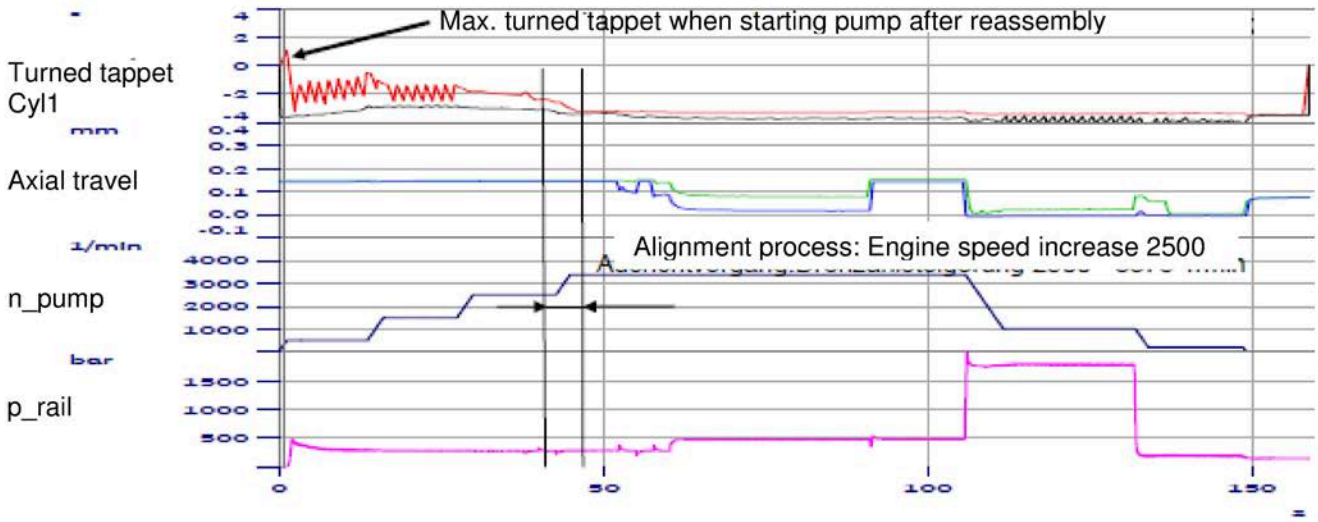
Overview of functional test measurements turned tappet CP4.1

Influencing factor: Engine speed

- During first start-up of the pump, the tappet combination is aligned starting from an engine speed of > 3000 rpm (the pump test is started at 3,375 rpm)

UH_AngleOfRotation_cyl1_seq_material_nmax3375_le_NewInstalled_0000
OH_AngleOfRotation_cyl1_seq_material_nmax3375_le_NewInstalled_0000
UH_axial travel_seq_material_nmax3375_le_NewInstalled_0000
OH_axial travel_seq_material_nmax3375_le_NewInstalled_0000
pump speed_seq_material_nmax3375_le_NewInstalled_0000
Rail pressure_seq_material_nmax3375_le_NewInstalled_0000

Starting after installation procedure
same as factory testing
n_max = 3375 rpm

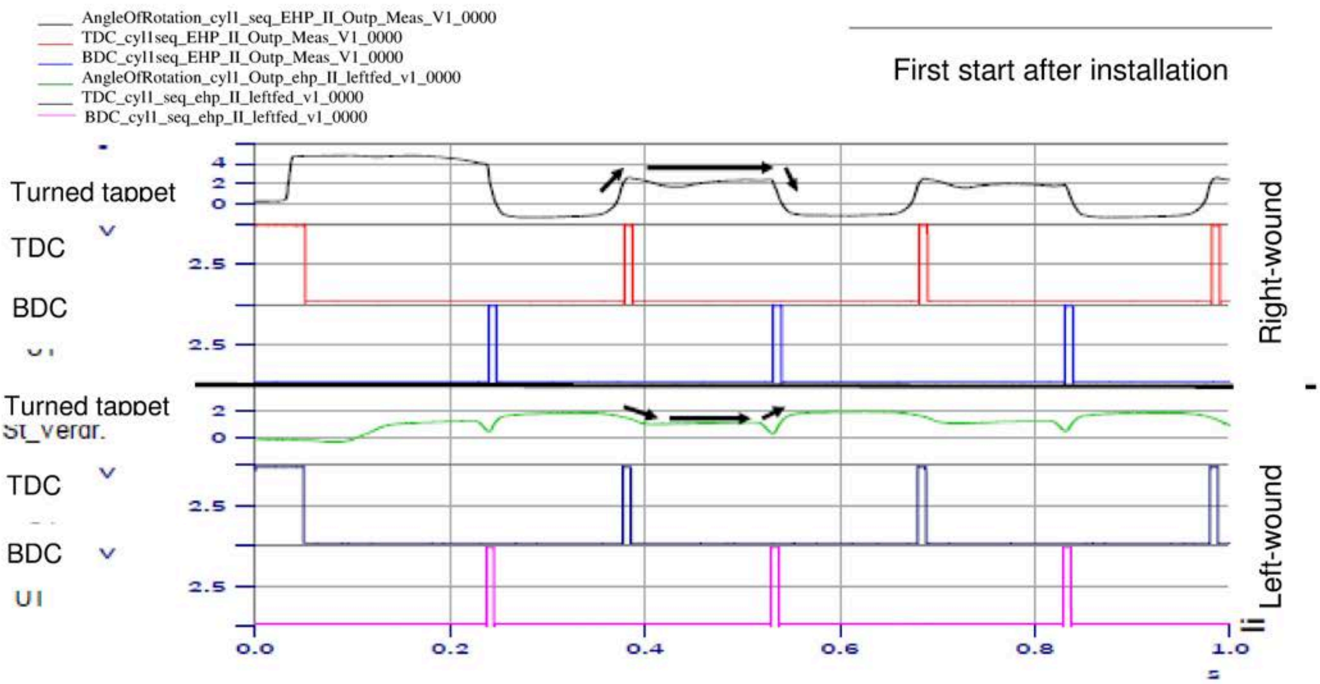


EA11003EN-00276[11]

Overview of functional test measurements turned tappet CP4.1

Influencing factor: Coiling direction of the spring

- Direction of movement of the tappet at US and LS depends on the spring turn direction



Diesel systems

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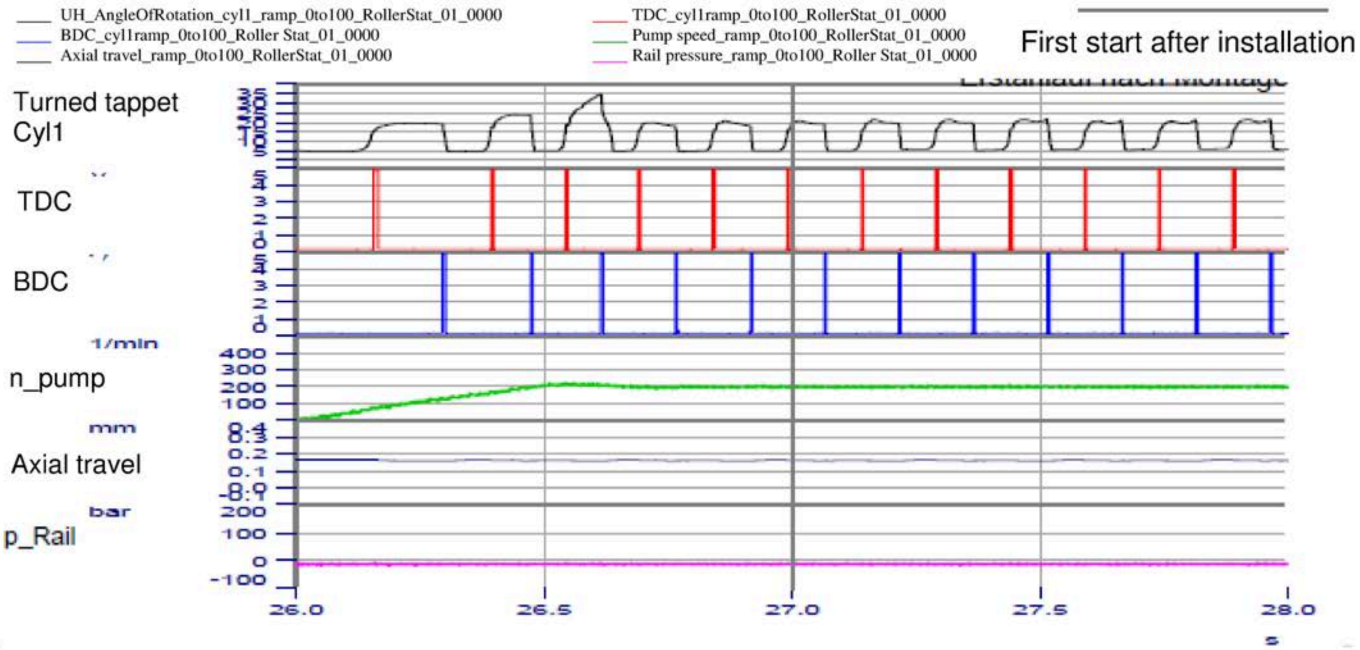
Overview of functional test measurements turned tappet CP4.1

Influencing factor: Roller stuck; detail

- Turned tappets in along US by about 15° and realigns along LS

First start after installation



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Overview of functional test measurements turned tappet CP4.1

Summary:

- Turned tappets > 10° were found only with stuck roller
- With stuck roller and turned tappets between 20 and 30°, the tappet combination realigns in the pump combination LS
- When starting the pump, turned tappets up to max. 6° are measured after assembly. These turns are reduced to a maximum of 1.5° after engine speed increase to n = 3,375 rpm or above
- No turned tappets > 3° are found even when the pump starts without rail pressure and at maximum engine speed of 100 rpm

Further work:

- Inspection of turn tendency with stiff rollers (choice of friction coefficient testing and tests with screwdriver bench)
- Further measurements with disc between ZK and upper spring, possibly lubricated
- Evaluate the influencing parameters of roller length
- Draft criteria for the recognition of the alignment process in the factory test
- Instrumentation of a BMW series pump (drawings completed, parts used in manufacturing)

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EA11003EN-00313[0]

From: Non-responsive content removed
To:
CC:
Date: 08.01.2008 15:07:00
Subject: Re: 071117_Corrosion in pumps and injectors / NAR failures
Attachments: 791110 Protokoll CP4 Fachgespräch am 21 11 07 bei [redacted] 3 .pdf
791199 Einsatz Wasserabscheider für US-Markt.pdf

I wish all of you in the distribution list a Happy New Year!

Hello Non-responsive content removed

According to me, the important topic of "Water separator, currently without feedback" is not over yet.
The fact that VW has no negative experience with the United States may be because no analyses were made (at least in the QA - see below).
We do not want to resort to the former VP37 analysis of 2002, right?
The Bosch numbers of 10 CoD / 1000 vehicles for a light-commercial vehicle manufacturer are still facts (see minutes of expert meeting on 11.21.07 - page 2, last point, and annex Bosch requirement)
To rely on the hope of refueling these light-commercial vehicles at other gas pumps like our Q7 would Be careless in my opinion.
Also the Bosch WCF Test with 300-500 ppm of water content (instead of 1%), specified by you does not help us any further, but only delays the decision.

SECTION CONFIDENTIAL

[redacted]
* Do you have analyses or concrete reports from VW?
* What else should we from QA do to convince the TE (or the Company)
to finally receive the feedback on water level? (Please do not tell that it's too late now)
* Please discuss the issue again with Non-responsive content removed and Non-responsive content removed

>With best regards
>
Non-responsive content removed

>____
>From: Non-responsive content removed
>Sent: Friday, 11.23.07 09:59:00
>To: Non-responsive content removed
>Subject: Re: 071117_Corrosion in pumps and injectors / NAR failures
>
>Hello [redacted]
>
>Sorry, but no one in the e-mail thread has analyzed US parts.
>Are there by any chance damage parts analyses from the US, for example at VWoA, etc.? (We All agree that there are complaints regarding the injection system)
>Does no one in the Group observe the US market???
>
>With best regards
>
>Non-responsive content removed

>
>____
>From: [redacted]
>Sent: Thursday, 11.22.07 19:16:00
>To: [redacted]
>Subject: Re: 071117_Corrosion in pumps and injectors / NAR failures
>
>
>Hello [redacted]
>
>On the part of SZ, there are no negative reports concerning corrosion problems.
>
>With best regards
>
>[redacted]
>38436 Wolfsburg
>[redacted]
>
>
>____
>From: [redacted]
>Sent: Saturday, 11.17.07 16:37:00
>To: [redacted]
>Cc:
>Subject: 071117_Corrosion in pumps and injectors / NAR failures
>
>Hello [redacted]
>
>Unfortunately, we do not have analyses on the aforementioned topic from the United States. For this reason, we can neither accept nor reject the proposal to omit the water separation step. See the response from BTV [redacted] in this regard.
>
>With best regards
>
>[redacted]
>Volkswagen AG
>[redacted]
>
>VOLKSWAGEN AG
>Domicile: Wolfsburg
>Court of Registry: Amtsgericht Braunschweig
Commercial Register No. /HRB Nr.: 100484

EA11003EN-00313[2]

>Chairman of the Supervisory Board: Ferdinand Piëch
>Board of Management: Martin Winterkorn (Chairman), Francisco J. Garcia Sanz, Jochem Heizmann, Horst Neumann, Hans Dieter Pötsch
>
>Important note: The above information is automatically added to this e-mail. This addition does not constitute a representation that the content of this e-mail is legally relevant and/or is intended to be legally binding upon Volkswagen Sachsen GmbH.
>Important Notice: The above information is automatically added to this e-mail. This addition does not constitute a representation that the content of this e-mail is legally relevant and/or is intended to be legally binding upon VOLKSWAGEN AG.
>
>
>
>____
>From: Non-responsive content removed
>Sent: Thursday, 11.08.07 13:59:00
>To: Non-responsive content removed
>Cc:
>Subject: 071108_Corrosion in pumps and injectors / NAR failures
>
>Hello Non-responsive content removed
>
>Regarding the issue of corrosion on diesel components, there are no failure figures, as analysis or RB were not performed at our place.
>You can certainly obtain data from failed components, but such data are not meaningful with regard to corrosion.
>Last in 2002, we analyzed 39 distributor injection pumps from the US market, wherein the main problem here was
>the insufficient lubricity of fuel (29 failures)
>Two distributor injection pumps were affected by corrosion at that time.
>
>Otherwise, we can make a statement only about the market in Non-responsive content removed We've got figures here.
>If you need information, please contact me.
>
>With best regards
>
>
>Non-responsive content removed
>
>Volkswagen AG Salzgitter
>Non-responsive content removed
>
>
>
>____ >
>From: Non-responsive content removed
>Sent: Wednesday,11.07.07 14:30:00
>To: Non-responsive content removed
>Cc:
>Subject: Re: Corrosion in pumps and injectors / NAR failures

>
>Hello [redacted]
>
>Can you please clarify with [redacted], whether we have observed failures / corrosion of diesel components caused by water (in this case, only pump/nozzle unizs, perhaps distribution injection pump and jets) in the US market (see also e-mail list of the South Group).
>
>With best regards
>
>[redacted]
>
>[redacted]
>VOLKSWAGEN AG
>[redacted]
>D-38231 Salzgitter
>Germany
>[redacted]
>
>
>____
>From: [redacted]
>Sent: Wednesday,11.07.07 9:31 AM
>To: [redacted]
>Cc:
>Subject: Re: Corrosion in pumps and injectors / NAR failures
>
>Hello [redacted] Hello [redacted]
>Please clarify and "R".
>Thank you
>
>____
>From: [redacted]
>Sent: Tuesday,11.06.07 18:36:00
>To: [redacted]
>Subject: Re: Corrosion in pumps and injectors / NAR failures
>
>Hello gentlemen,
>
>Are you aware of the problems, as described in the mail from [redacted] or can we implement the omission of water drain plug (as planned) with CR engines?
>
>
>With best regards
>
>[redacted]
>38436 Wolfsburg
>[redacted]

\>Non-responsive content removed
\>
\>
\>
\>____
\>From Non-responsive content removed
\>Sent: Tuesday,11.06.07 9:52 AM
\>To: Non-responsive content removed
\>Cc:
\>Subject: Re: Corrosion in pumps and injectors / NAR failures
\>
\>Hello Non-responsive content removed
\>
\>[redacted] has apparently done it already (see his mail - point 3).
\> I have requested specific statements from Bosch - I will get back to you.
\> <Message: Re: Corrosion in pumps and injectors / NAR failures >>
\>
\>Hello [redacted]
\>Can VW QA support / confirm the omission of water separation step in the USA?
\>or agree to the facts 1-5 in the Annex?
\>
\>With best regards
\>
\>Non-responsive content removed
\>
\>
\>AUDI AG
\>[redacted]
\>85045 Ingolstadt
\>Non-responsive content removed
\>
\>
\>
\>http://www.audi.com
\>
\>____
\>From: Non-responsive content removed
\>Sent: Tuesday,11.06.07 8:06 AM
\>To: Non-responsive content removed
\>Cc:
\>Subject: Re: Corrosion in pumps and injectors / NAR failures
\>
\>Hello,
\>I recommend inquiring with Non-responsive content removed; they have been active for years with TDI in series in the USA.
\>
\>Best wishes,
\>Non-responsive content removed

>
>With best regards
>
>Non-responsive content removed
>
>AUDI AG
>Non-responsive content removed
>74148 Neckarsulm
>Non-responsive content removed
>www.audi.com
>Domicile: Ingolstadt
>Court of Registry: District Court of Ingolstadt
>Commercial Register No.: 1>
>Chairman of the Supervisory Board: Martin Winterkorn
>Board of Management: Rupert Stadler (Vorsitzender/Chairman), Ulf Berkenhagen, Michael Dick, Frank Dreves, Axel Strotbek, Ralph Weyler, Werner Widuckel
>
>
>
>
>____
>From: Non-responsive content removed
>Sent: Tuesday, 10.30.07 15:38:00
>To: Non-responsive content removed
>Cc:
>Subject: Re: Corrosion in pumps and injectors / NAR failures
>
>Hello Non-responsive content removed
>
>I got the following information upon your request:>
>
>Audi failures of the high-pressure pump and injector (mostly domestic):
>* High-pressure pump none are known
>* Injectors: slightly increasing, injector's year of manufacture 2004 - 1 case, year of manufacture 2005 - 3 cases; year of manufacture 2006 - 9 cases.
>
>Important additional information:
>* There is a major German OEM in NAR, which operates with water separation and combination indicator in series => it has no known failure problems! Here, the information that there are regions, where the indicator hardly responds and other regions with very frequent display, is interesting.
>* There is a well-known American OEM in NAR, which started operation with water separation and planned combination indicator in series, but because of own software error it does not have a sharp display => it has huge problems with CoD larger than 10/1000 vehicles. !!!
>

>The system suppliers strongly recommend to switchover to water separation with indicator in combination!

>

>

>With best regards

>

>[redacted] Non-responsive content removed

>

>AUDI AG

>[redacted]

>85045 Ingolstadt

>[redacted] Non-responsive content removed

>http://www.audi.com

>

Diesel Systems

BOSCH

From	Persons responsible	Tel	Fax
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]
November 22, 2007
No. 791110

Protocol

Recipient TN Audi: [redacted]
TN RB: [redacted]

Invited [redacted]
Participant:
Line: [redacted]
Protocol
Organis.
Date/venue **21.11.2007, 11:00 - 1:30 p.m., [redacted], B12, middle meeting room.**
Topic **CP4 Specialist Meeting**

OPL status

The latest outstanding points from the OPL were presented Further points will be added to the OPL from the specialist meetings and from the findings meeting. [redacted]

Complete overview of RB continuous running tests [redacted]

Bosch presented the current status of RB's examination of component continuous running tests. A fused flange bearing was found on a CP4.2 platform pump after a continuous running test. The pump is conditionally released. Other investigations are planned.
Two more pumps have passed the continuous running test with restrictions (wear on the shaft seal of the gear pump). It was agreed with Audi that the findings report for the gear pump will be presented. [redacted]
The V8 pumps have passed the continuous running test without any striking features.
There has been no new information from the US continuous running tests since the last specialist meeting. In relation to the smoothing and polished surfaces identified in a visual check on the camshaft. Bosch found that the test bench turns at a much slower speed. Bosch is checking at the moment to see whether a genuine standstill is possible on the test bench. [redacted]
Bosch presented the latest status on the US VW continuous running tests. 8 pumps run on the test bench and 4 pumps in the vehicles themselves. At present we still lack the results from two vehicle continuous running tests. The worst rating in all other continuous running tests was 4. The rating levels are divided from 1 to 10. Rating 1 is very good. 10 is understood to indicate a total write-off.
It was found that the lubrication of the US fuel ranged from 345µm to 544µm. This information indicates that the US fuel is better than originally expected, which is confirmed by the long running times of the US vehicles.
There are plans for another set of system continuous running tests with GDK570 at

From [redacted] | Persons responsible [redacted] | Tel [redacted] | Fax [redacted]

[redacted]

November 22, 2007
No. 791110

Protocol

CP4 Specialist Meeting

Bosch. In the case of customer VW, the vehicle trial with pump CP4.1 is not yet complete. The pump is currently subject to a conditional release.

Pump failure status [redacted]

Bosch presented the latest status on the failures due to powertrain damage and reversed tappets. It is clear that the measures are taking effect because the number of failures is decreasing as the production volume rises. Audi wants a regular revision of the customer slides relating to failures. [redacted]

Bosch also presented the current status in relation to the failure of splintered O-rings in the metering unit. Remedial measures were defined by Bosch and will be presented to the customer separately [redacted]

Volume balance CP4.2H for V8 [redacted]

Bosch presented the initial situation and the current status from week WK 47. The measurement evaluation shows that Bosch is well within the upper range with 5-8 l/h reserve. Bosch is planning further checks and evaluations of the characteristic curves. [redacted]

SECTION CONFIDETIAL

Engine trial CP4.2 with turned tappet [redacted]

Bosch presented the current status of the engine trial with reversed cam follower. In relation to the damage, Bosch assumes that the torque of the high-pressure fuel pump was too great. Testing of the faulty pump continued on a torque stand and the result was compared with a new pump. In addition, Bosch planned to set up a torque measurement pump with sticking roller and to carry out torque measurements. A separate date is planned for the Dresden failures.

Termin: Ende 2007

[redacted]

Water separator (WA) (Use of WA system)

Audi is currently planning a water separator without filling sensor for use in the USA. Bosch requirement for markets in which fuel quality according to EN590 cannot be assured Bosch requires the use of a water separator with feedback (warning lamp). RB experience in the field in the USA indicates that customers with a water separator and filling sensor have no problems with corrosion, but that in the case of customers without a filling sensor there are

10 cases of damage per 1,000 vehicles.

From Audi's perspective, the wcf test at RB with 1% water is unrealistic and should be repeated with a water proportion of 300 ppm and a maximum of 500 ppm. [redacted]

SECTION CONFIDETIAL

[redacted]

From: Non-responsive content removed [redacted]
To: [redacted]
CC: [redacted]
Date: 11/16/2009, 10:00:00 AM
Subject: Re: Presentation from CP4 technical discussion
Attachments: 887 1239 water in fuel.pdf
[redacted] [redacted].pdf
Wasserabscheidung im Kraftstoffsystem Aggregatekreis [redacted].ppt

For your information.

With best wishes

Non-responsive content removed [redacted]

From: Non-responsive content removed [redacted]
Sent: Friday, November 13, 2009, 4:40 PM
To: Non-responsive content removed [redacted]
Cc: [redacted]
Subject: Re: Presentation from CP4 technical discussion

Hello Mr. [redacted]

I wasn't able to reach you by phone.

Do you mean dissolved water or "mixed" as a water-Diesel emulsion -> formed through free water in the vehicle tank and turbulence through the EFPs?

Dissolved water
- Lubricity and viscocity for dissolved water are comparable to pure Diesel fuel
- Filling station fuel contains water at the limit of solubility, since the tank bottom of the filling station always contains free water.

The proportion of dissolved water is dependent on various parameters (such as temperature, biodiesel).

Free water is created when operating conditions change (for example, operation vs. standstill, ...)

In addition, free water can enter the vehicle's fuel tank through a variety of methods (for example, through the tank ventilation, filling at a filling station that was recently refilled by a tank truck, which whirled up the water on the filling station tank bottom).

We had a expert presentation by Non-responsive content removed [redacted] - see attachment - page 11/12 illustrates a mechanism of how free water arises in "normal" operation.

[redacted] confirmed this process in a later presentation (see PPT presentation)

If free water (water droplets) reaches the tribological contact points (roller-cam and roller-roller support), then we - sometimes - have water substance parameters in which the viscosity/lubricity lie outside of what our pump can tolerate.

SECTION CONFIDENTIAL

Our pump was damaged with 500ppm water (approx. 70ppm dissolved, 430 ppm free water). 200 ppm water (70ppm dissolved, 130 ppm free water) did not do any apparent damage to the pump.

As you can see from the CP4 Robustness presentation, additional investigations are planned to gain an exact understanding of the influences and damage mechanisms (Page 25, further action).

In addition:
- We will discuss the fuel parameters on the world market Non-responsive content removed on 12/8/2009.
- There are activities on your side Non-responsive content removed to assess the future use of a high-value water separator.

Please feel free to contact me if you have any other questions.

Best regards / mit freundlichen Grüßen

Non-responsive content removed

Robert Bosch GmbH
Non-responsive content removed
GERMANY
www.bosch.com

Non-responsive content removed

From: Non-responsive content removed
Sent: Friday, November 13, 2009, 12:20 PM
To: Non-responsive content removed
Cc:
Subject: Re: Presentation from CP4 technical discussion

Hello Non-responsive content removed

Have you examined how the lubricity of the Diesel responds dependent on the water content, for example, according to DIN EN ISO 12156-1?

With best wishes

Non-responsive content removed

AUDI AG
Non-responsive content removed

From: [redacted]
Sent: Thursday, November 12, 2009, 6:13 PM
[redacted]
Subject: Re: Presentation from CP4 technical discussion

Dear [redacted]

We have answered Mr. [redacted] with regard to your mail.

Please feel free to contact us if you feel the need to discuss the matter further.

Sincerely

[redacted]

Robert Bosch GmbH
[redacted]
GERMANY
www.bosch.com

[redacted]

From: [redacted]
Sent: Wednesday, November 04, 2009, 7:28 PM
[redacted]
Subject: Re: Presentation from CP4 technical discussion

.. please provide the evidence for the hydrogen brittleness and stress corrosion cracking (laboratory analysis reports).
Or remove the hypotheses - that is, delete them from the presentation!

With best wishes

[redacted]

From: [redacted]
Sent: Friday, October 30, 2009, 2:58 PM
To: [redacted]
Subject: Re: Presentation from CP4 technical discussion

EA11003EN-00325[3]

Hello [redacted]

I see only fatigue damage due to overload from the damage symptoms. Water could possibly reduce lubricity and/or result in earlier mixture friction, thus increasing susceptibility of damage. The idea that water results in hydrogen brittleness and stress corrosion cracking is not apparent in my eyes. We would need firm evidence of this, based on examination of the damage and surface of the break. I don't think this is likely.

On the subject of water induction in Diesel. The Diesel analysis maps worldwide show that in 99% of all cases, we have less than 200 ppm, in most cases not even 100 ppm H20, which does not result in any problems in tests. Is there really a need to harden up against higher water content?

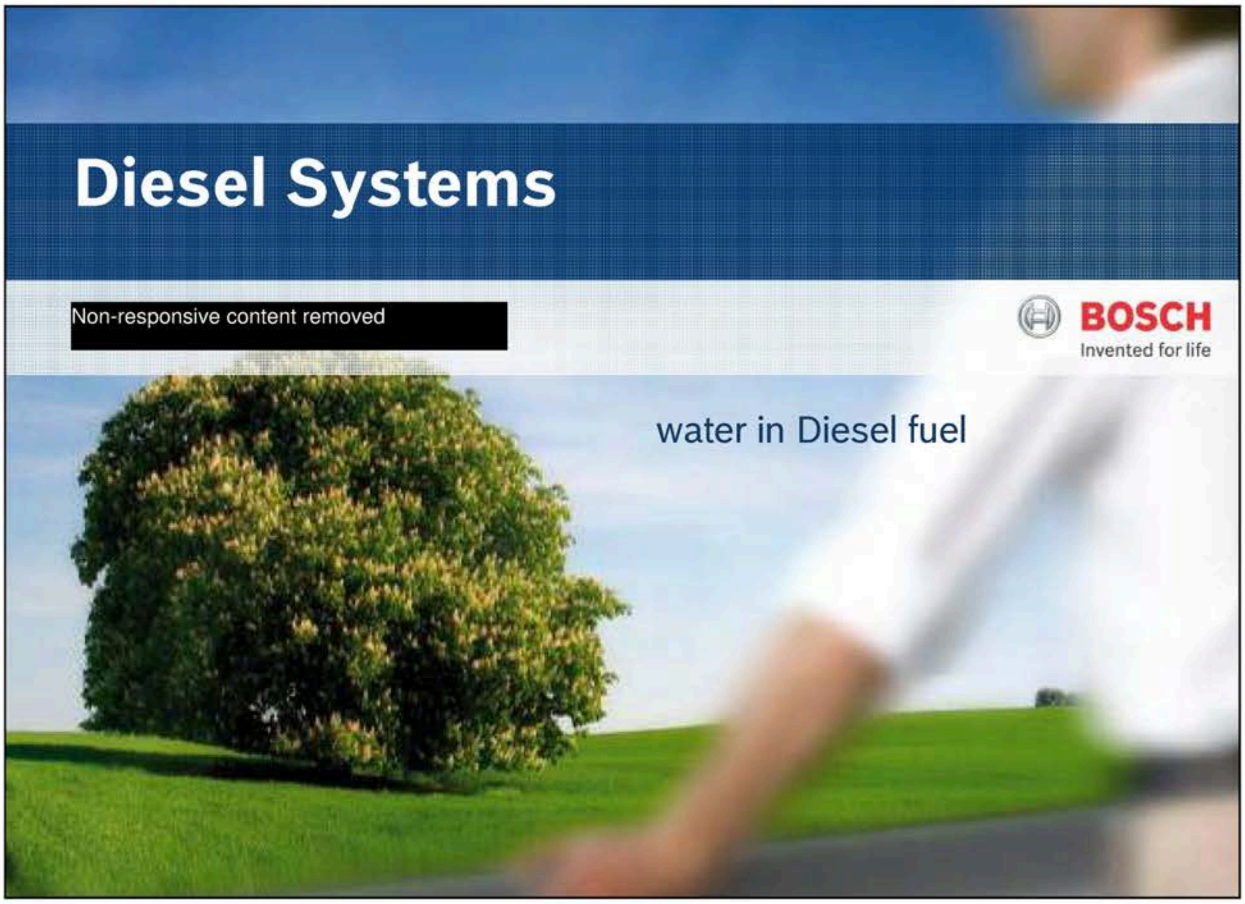
Best wishes,

[redacted]

From: Non-responsive content removed
Sent: Friday, October 23, 2009, 10:06 AM
To: Non-responsive content removed
Subject: Re: Presentation from CP4 technical discussion

With best wishes

Non-responsive content removed



Fuel Quality Aspects - Water

Contents

- failure types and wear mechanisms caused by water
- why do we get corrosion?
  - anti-corrosive properties of Diesel fuel
  - undissolved water in the FIE, where does it come from?
- corrosion in the field, what is the main driver ?
  - water content [redacted] compared to the U.S.
  - survey data of anti-corrosive properties [redacted] and the U.S.
  - effect of corrosive attack and anti-corrosive properties
- wear
- hydrogen wear
- summary and conclusion
- the wcf corrosion test

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Fuel Quality Aspects - Water

Contents

- failure types and wear mechanisms caused by water
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Fuel Quality Aspects - Water

Failure types and wear mechanisms caused by water

- **Corrosion**
  undissolved water combined with insufficient anti-corrosive properties of the fuel leads to corrosion
- **Increased wear**
  in the presence of water a significant increased wear can be observed
- **Hydrogen wear**
  certain boundary conditions (depending on material, very high local compression) will lead to hydrogen wear in the presence of water

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Contents

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Fuel Quality Aspects - Water

Why do we get corrosion ?

corrosion inside our FIE has 2 parents

1. free (=undissolved) water

2. bad anticorrosive properties of Diesel fuel

pump

corrosion can lead to a direct malfunction or to a consecutive failure by rust particles

valve body injector

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Fuel Quality Aspects - Water

Anti-corrosive properties of Diesel fuel

- anticorrosive properties of Diesel fuel can be determined and classified by the NACE TM0172 test
  (we apply NACE_mod with artificial sea water instead of distilled water)
  alternative standards are ASTM D665, ISO 7120
- this test method was for a long time used in AAM [redacted] Fuel Survey (unfortunately cancelled in 2008)
- Bosch has introduced this method to some surveys by SGS
  (e.g. U.S. Diesel & BioDiesel Survey summer 2006
  special survey data of the world wide SGS fuel survey, ...)

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Fuel Quality Aspects - Water

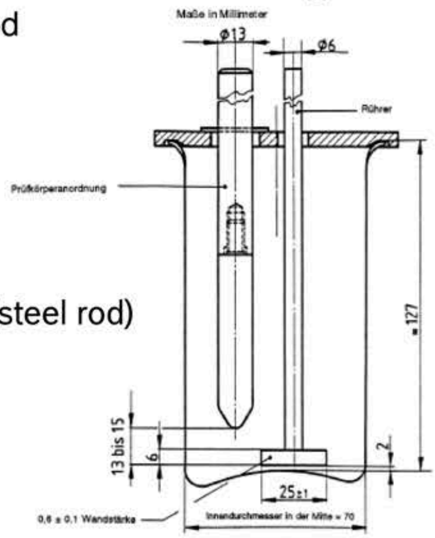
Anti-corrosive properties of Diesel fuel

Standardized lab tests: NACE TM0172_mod
DIN ISO 7120

Test principle:

- put test fuel into beaker
  (test temperature ISO: 60°C, NACE 38°C)
- start the stirrer and place the test specimen (steel rod) in the beaker
- add 10% artificial sea water
- run the test (ISO: 24h, NACE 3,5h)
- assess the test specimen by rating A - E

test arrangement



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Fuel Quality Aspects - Water

Anti-corrosive properties of Diesel fuel

Rating: per NACE TM0172

NACE-rating	% of test surface corroded
A	0
B++	< 0,1
B+	< 5
B	5-25
C	25-50
D	50-75
E	75-100

Fuel Quality Aspects - Water

Undissolved water, where does it come from?

undissolved water can pass the (non-ideal) water separator

or

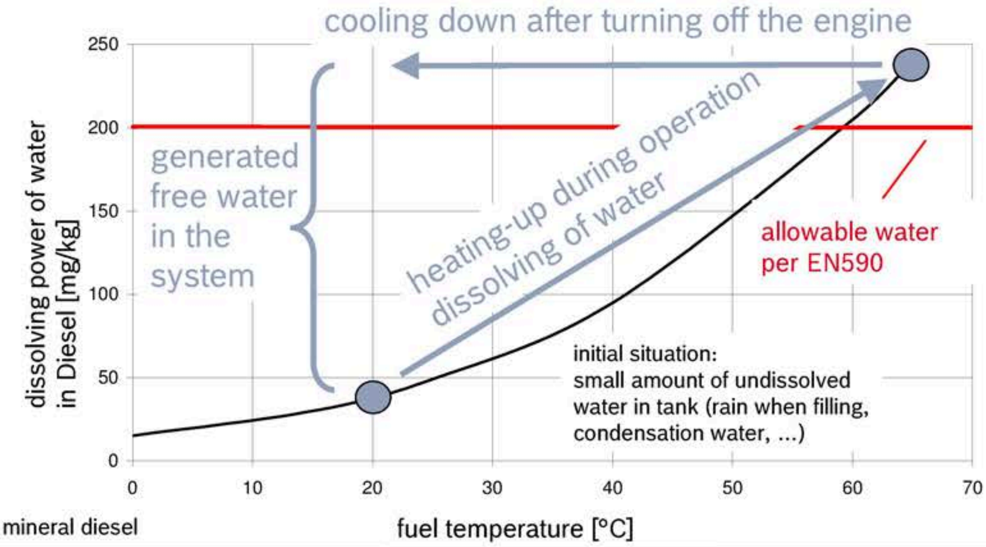
undissolved water can be "generated inside the system"

- → dissolved water passes the water separator at high fuel temperature
- → after turning off the engine the water gets undissolved due to cooling down

Fuel Quality Aspects - Water

Undissolved water, where does it come from?

mechanism of „generating free water“ inside the FIE



characteristic of a mineral diesel

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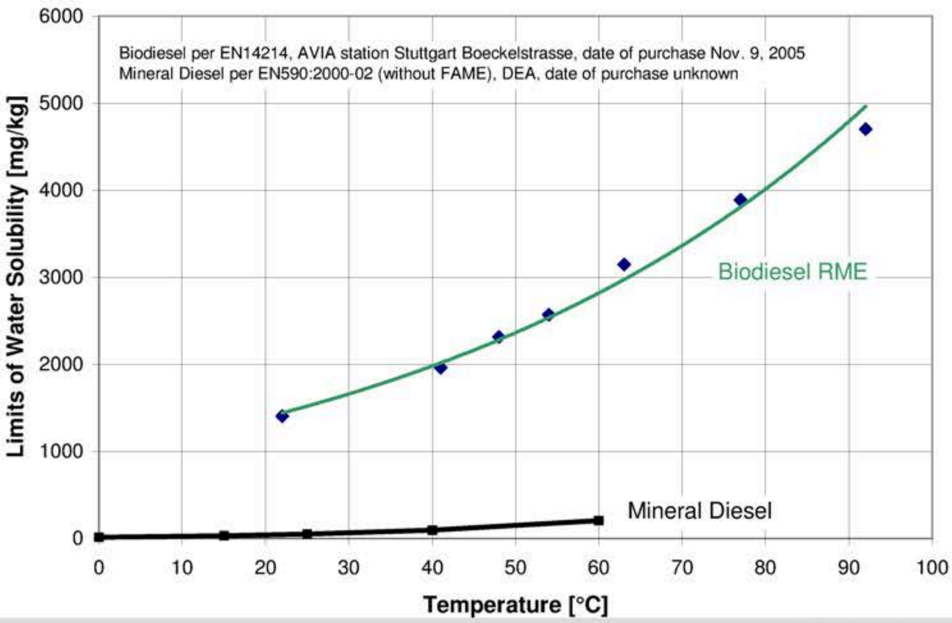
Fuel Quality Aspects - Water

Dissolving power of water in mineral Diesel & Biodiesel



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Fuel Quality Aspects - Water

Undissolved water, where does it come from?

conclusion

- there is water slip even using an ideal water separator
- because of the higher water dissolving power of Biodiesel the water slip by temperature effect is much higher (the higher the Bx portion, the higher the water slip)
- in addition with Biodiesel(blends) the efficiency of most water separators is dramatically reduced

the risk of having small amounts of undissolved water inside the system is inevitable

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Fuel Quality Aspects - Water

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  - effect of corrosive attack and anti-corrosive properties
- wear
- hydrogen wear
- summary and conclusion
- the wcf corrosion test

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Fuel Quality Aspects - Water

Corrosion in the field, what is the main driver?

situation

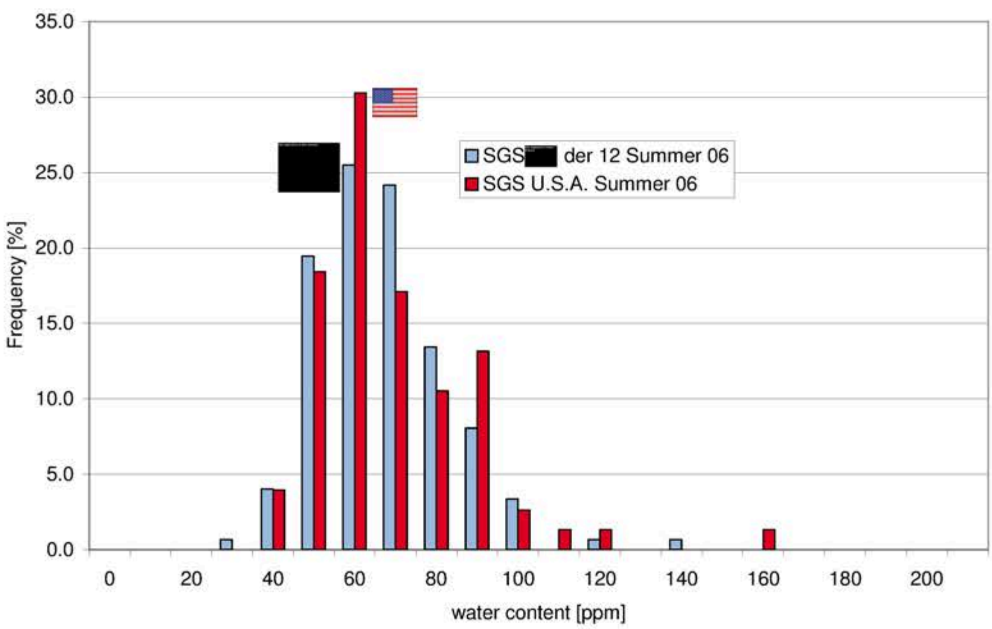
- the corrosion failure situation varies from market to market
- the U.S. is significantly more affected than [redacted]

what is the difference in the field situation?

- the water content in fuels ex gas station in the U.S. and the [redacted] is comparable (see following slide)
- but the anticorrosive properties of U.S. fuel are different from [redacted] fuel

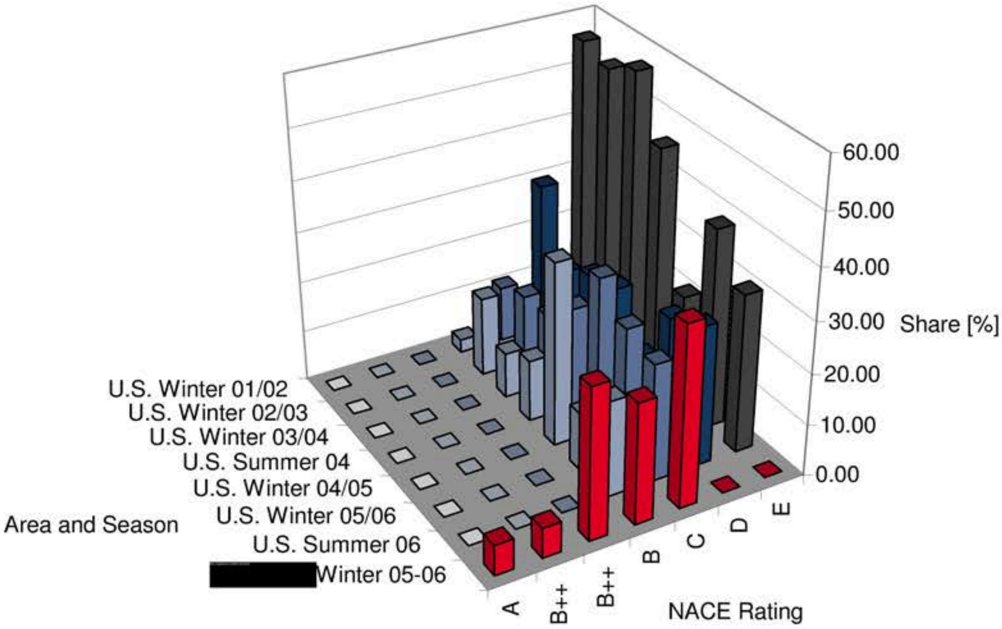
Fuel Quality Aspects - Water

Water content, survey data, U.S.A. and [redacted] of 12



Fuel Quality Aspects - Water

Anti-corrosive properties of Diesel fuel, U.S.A and [redacted]



Fuel Quality Aspects - Water

Effect of corrosive attack in lab test

corrosion depends mainly on anti-corrosive properties of fuel and hardly on the corrosive attack

NACE test of NACE=C fuel
10% artificial sea water

NACE test of NACE=C fuel
10% distilled water

NACE test of NACE=E fuel
10% artificial sea water

NACE test of NACE=E fuel
10% distilled water

Fuel Quality Aspects - Water

Effect of anti corrosive fuel properties in rig test with FIE

Common Rail Injector CRI2.2
1% diluted artificial sea water
test duration: 168 h (7 days)

valve spring | valve ball seat | valve body

NACE = A

no corrosion even after 1 week in service

NACE = C

CRI out of spec. after 100h works hardly after 1 week

NACE = E

CRI destroyed by corrosion after short time

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Fuel Quality Aspects - Water

Why was corrosion not that big issue in the past ?

attempt of an answer

- oil lubricated system insert engine oil to the fuel. This improves the anti-corrosive properties of the fuel (see next slide)
- oil lubricated systems have less contact with fuel
- fuel temperatures in the tank are lower with non-CR systems, therefore the described "water dissolving effect" is lower
- dissolving power of water was lower due to lower additive concentrations and no BioDiesel blends

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Fuel Quality Aspects - Water

Anti-corrosive effect of engine oil in the Diesel

NACE tests with

pure Diesel NACE = D	100ppm engine oil added			
	synthetic	mineral		engine oil
	0W30	15W40	10W10	

typical engine oil dosing rates for oil lubricated FIE (CP3.4, CP2, PF45): 30-200ppm

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Fuel Quality Aspects - Water

Anti-corrosive properties of Diesel fuel

conclusion

- Sooner or later there is undissolved water inside the FIE
- Undissolved water leads to corrosion if the anticorrosive properties of the fuel are bad
- The occurrence of corrosion depends on the probability of having undissolved water inside the FIE and on the probability distribution of the anti-corrosive properties of the refueling fuel mixture
- The failure mode and robustness w/r/t corrosion depends on the components. This could be particles, seize up, plugging or fracture.

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Fuel Quality Aspects - Water

Corrosion in the field

outlook

- the field situation in the U.S. is tending to get improved by
  - Biodiesel blending leads to improved anti-corrosive properties until it is non-aged
  - U.S. Diesel currently uses higher additive rates due to the switch to ULSD and the consecutive need for lubricity improvement
  - U.S. mineral oil companies switch from acid based lubricity additives to ester based lubricity additives

however

- **anti-corrosive properties of fuel are not standardized in any fuel standard worldwide**

Fuel Quality Aspects - Water

Contents

Fuel Quality Aspects - Water

Wear

→ **water causes tribocorrosion**

Common Rail pump CP3.2+

30h in service with 1% diluted sea water (1:10)

500h in service without water

1400% wear
at 6% runtime

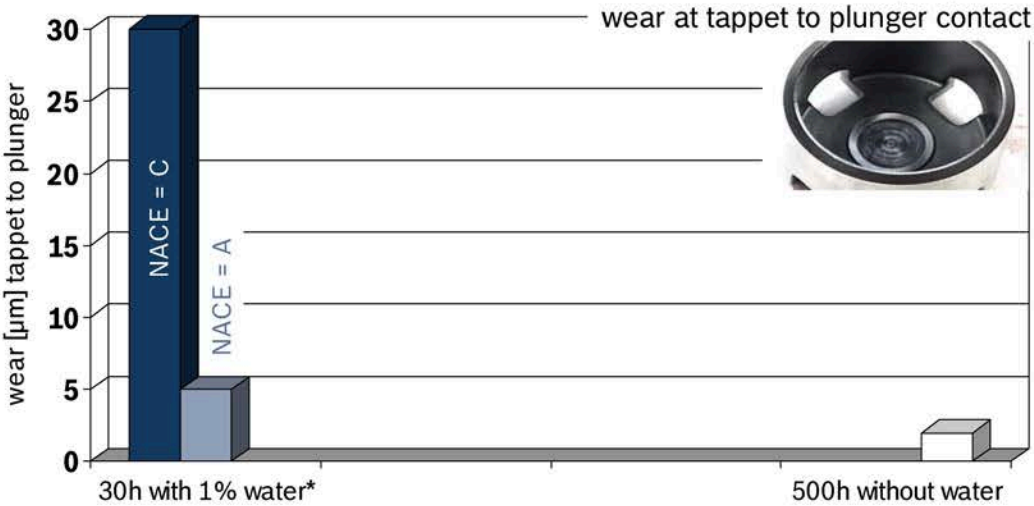
wear at
tappet to plunger
contact

BOSCH

Fuel Quality Aspects - Water

Wear

water in fuel causes strong wear at highly loaded tribological contacts



* 1:10 diluted artificial sea water

lubricity of all fuels: 380-430µm

BOSCH

Fuel Quality Aspects - Water

Wear

- water in fuel causes strong wear at highly loaded tribological contacts
- after 30h in service with 1% water we find an immense wear compared to 500h in service without water
- even with a NACE=A fuel (no corrosion at all after 7 days in service with 1% water) we find after 30h higher than doubled wear compared to 500h in service without water

- water is an essential cause for immense wear in the FIE
- even if the system is not corroding due to excellent anti-corrosive properties of the fuel, water will lead to heavy wear
- we need a water separator to be sure

BOSCH

Fuel Quality Aspects - Water

Contents

- failure types and wear mechanisms caused by water
- why do we get corrosion?
  - anti-corrosive properties of Diesel fuel
  - undissolved water in the FIE, where does it come from?
- corrosion in the field, what is the main driver ?
  - water content [redacted] compared to the U.S.
  - survey data of anti-corrosive properties [redacted] and the U.S.
  - effect of corrosive attack and anti-corrosive properties
- wear
- hydrogen wear
- summary and conclusion
- the wcf corrosion test

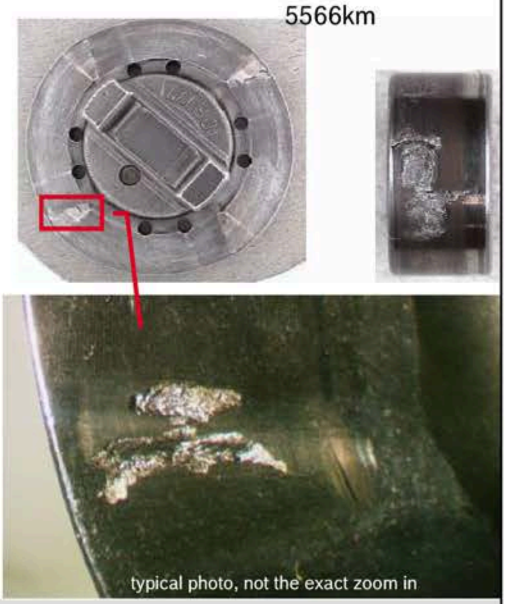
BOSCH

Fuel Quality Aspects - Water

Hydrogen wear

- very high local compression intrudes atomic hydrogen to the steel. By increasing the volume at recombination into H_2 the structure of the steel is demolished (like freezing water)
- experience from rig tests:
  2% distilled water, damage after ca. 70h
  2% sea water, damage after ca. 20h
- could become important again for new roller-cam driven pumps

vehicle in the field
5566km



BOSCH

Fuel Quality Aspects - Water

Contents

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Fuel Quality Aspects - Water

Summary and conclusion

- Fuel must be free of undissolved water to prevent the FIE from failure. This is not only due to corrosion, but also due to wear
- Fuel must contain enough anti-corrosion additives to prevent from corrosion. A water separator is necessary but not sufficient.
- The requirements to water separation rise because of increasing BioDiesel shares. Furthermore electric fuel pumps and jet pumps generate more stable emulsions with smaller water droplet size that reduce the separation efficiency.
- Fuel characteristics that influence water separation efficiency (interfacial tension IFT and separability MSEP) are important factors and shall be known market specific (activities just started)

BOSCH

Fuel Quality Aspects - Water

Contents

- failure types and wear mechanisms caused by water
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  - effect of corrosive attack and anti-corrosive properties
- wear
- hydrogen wear
- summary and conclusion
- the wcf corrosion test

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Water Contaminated Fuel Test for Corrosion

Aim:

robustness analysis of FIE component reliability with respect to water contaminated fuel

Description:

- load-change profile - idle, medium and high load
- fuel with medium anti-corrosive properties (NACE=C) and 1% (salty) water
- both indicator test for FIE comparison and release test with runtime targets based on experience

Running Time Target

- ***based*** on experience (no field problems known with CRI2)
- ***until 24 h***:
  full function of the product within TCD limits is given (*within all tolerances*)
- ***until 72 h***:
  - *function* is given. Significant differences to the TCD field tolerances are allowed, but no shutdown of the engine
  - no sticky or seized up machine elements
- ***at test end (168 h):***
  no failures with severity 10 (in terms of FMEA)

EA11003EN-00328[0]

Audi

Water separation in the fuel system

ENTIRE PAGE CONFIDENTIAL

EA11003EN-00328[1]

Necessity - Water separation in the fuel system
Classification for critical countries

Number	Country	Water content max. mg/kg	Measurements OK	Measurements Not OK	Free water available
1	Non-responsive content removed [redacted]	32300	45	1	x
2	[redacted]	10840	20	1	
3	[redacted]	5800	52	2	x
4	[redacted]	5264	54	1	
5	[redacted]	3884	22	3	x
6	[redacted]	3338	20	6	x
7	[redacted]	1786	11	4	x
8	[redacted]	1250	7	8	x
9	[redacted]	1028	6	3	
10	[redacted]	626			
11	[redacted]	612			
12	[redacted]	582			
13	[redacted]	453			
14	[redacted]	398			
15	[redacted]	397			
16	[redacted]	374			
17	[redacted]	338			
18	[redacted]	325			
19	[redacted]	308			
20	[redacted]	304			
21	[redacted]	293			
22	[redacted]	277			
23	[redacted]	277			
24	[redacted]	277	26	1	
25	[redacted]	258			
26	[redacted]	246			
27	[redacted]	241			
28	[redacted]	223			
29	[redacted]	223			
30	[redacted]	214			
31	[redacted]	201			
32	[redacted]	142	134	0	
		149	31	0	

4BZ_686150_Anlage
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Other countries with free water content in samples:

Non-responsive content removed [redacted]

Coordination to follow up to CW 24 for:

Non-responsive content removed [redacted]

Future coordination every 6 months in the country control circuit

Necessity - Water separation in the fuel system
Conditional suitability of current water separator

Audi

Premise: for each filling with 70 l fuel + 1 l free water

Vehicle consumption 7 l/100 km

Current water separator (93% acc. specifications from Bosch)

1 l water to 70 l fuel = 17 000 mg/kg

Mileage	Separated water	Water in the HP system
1000 km	0.93 l	0.07 l
10 000 km	9.3 l	0.7 l
30 000 km	27.9 l	2.1 l

DIN EN 590 limit 200 mg/kg

60 000 km	0.066 l	0.005 l

Despite the separator, over mileage of 1000 km the amount of water in the HP system exceeds 14 x the "limit" specified by Bosch!

The customer must empty the water reservoir (90 - 200 ml) every 100 - 200 km!

Necessity - Water separation in the fuel system
Conditional suitability of current water separator

Audi

Tests at Non-responsive content removed

D3 V6 TDI (HN-ZJ 217), part no. fuel filter 057 127 435 E (water reservoir 90 ml)

Test:
- Water reservoir in the **filter compartment filled with 90 ml** (filter paper does not dip into the water)

Result:
- **5871 km mileage**
  - **21 ml free water in the filter compartment**

D3 V8 TDI (HN-BW 628), part no. fuel filter 057 127 435 E (water reservoir 90 ml)

Test 1:
- Water reservoir in the **filter compartment filled with 200 ml** (filter paper dips into the water)

Result 1:
- **1550 km mileage**
  - **47ml free water in the filter compartment**

Test 2:
- **Vehicle filled with 80 l fuel and + 2 l water**

Result 2.1:
- **4463 km mileage** (without adding more water)
  - **30 ml free water in the filter compartment**

Result 2.2:
- **7700 km mileage** (without adding more water)
  - **No free water in the tank**

EA11003EN-00328[4]

Necessity - Water separation in the fuel system
Technical - physical limits

Audi

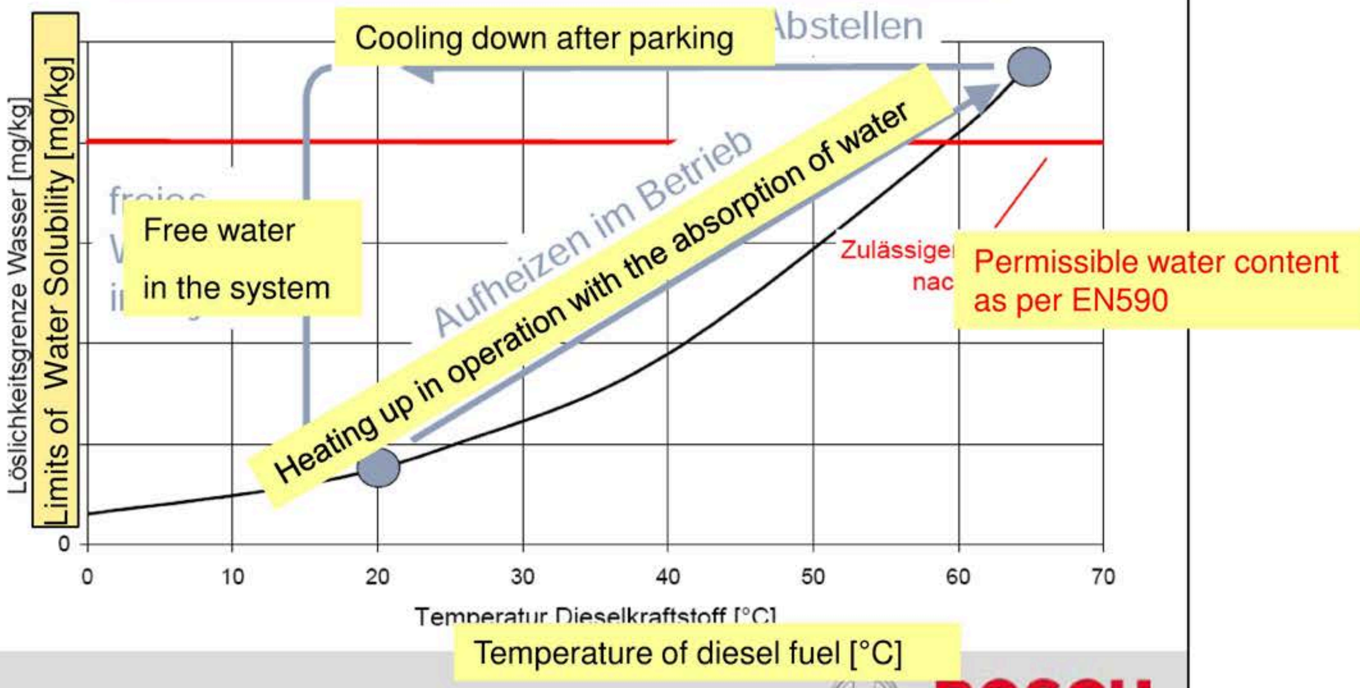
System-related free water despite separation

Filtergrüsentation AUDI, NSU, 22.01.2007
Filter presentation AUDI, NSU, January 22, 2007

Water-related damage-causing mechanisms

→ Corrosion

Origin of the mechanism of free water in the FIE



BOSCH

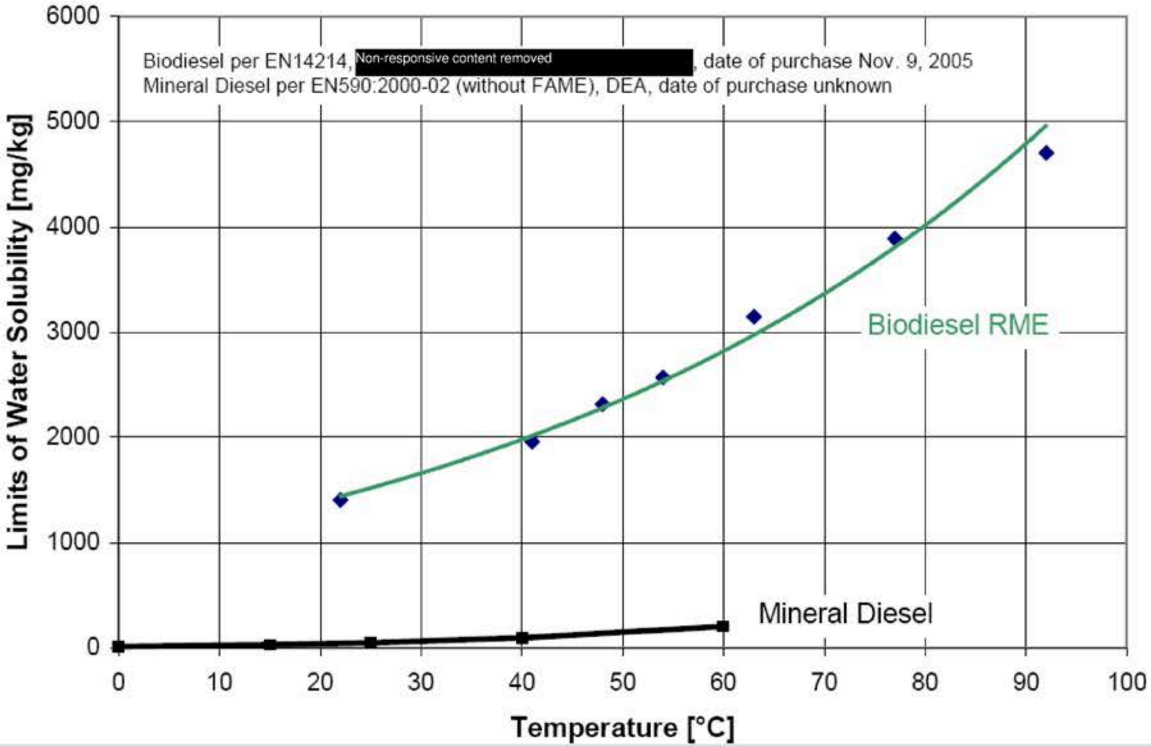
Necessity - Water separation in the fuel system
Technical - physical limits

Audi

Water absorption capability in the fuel system

Filter presentation AUDI, [redacted] January 22, 2007

Dissolving Power of Water in Mineral Diesel & RME



26 [redacted] | 15.08.2006 | 688 386 |

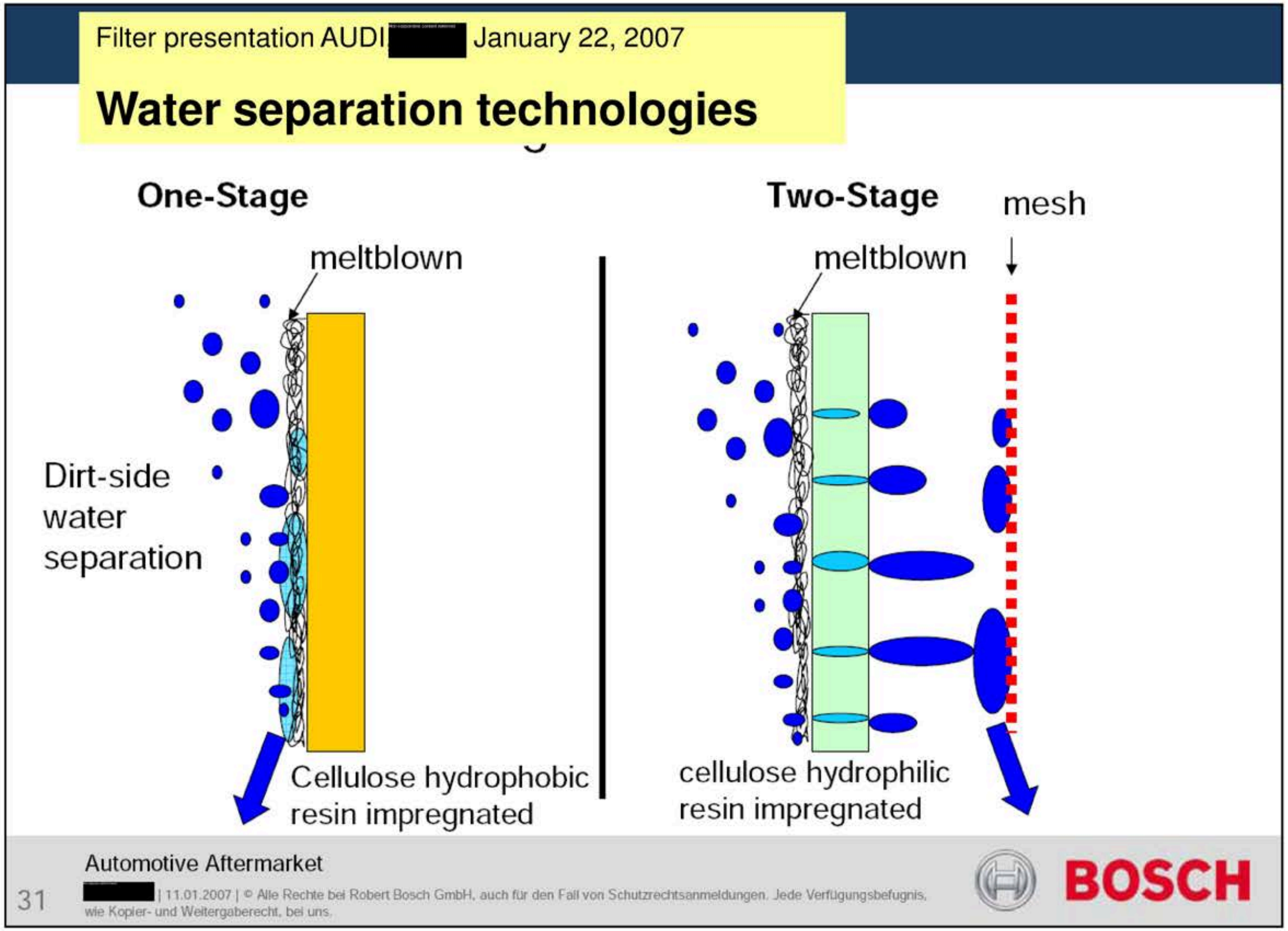
BOSCH

EA11003EN-00328[6]

Water separation in the diesel fuel system

Audi

Water separation function



Necessity - Water separation in the fuel system
Technical - physical limits

Water separation with biodiesel

-Biodiesel can dissolve considerably more water (factor 20) than diesel as per DIN EN 590

- With a biodiesel proportion of >5%, the separation efficiency of a water separator is reduced from 93 to 35%

An efficient, practical water separation is no longer provided in this scenario!

Necessity - Water separation in the fuel system
Risk assessment and measures

Decision recommendation

Audi: No use of additional water separators for critical countries!
Volkswagen: Use of existing water separators for critical countries!

-Establishment of water content up until which the damage-free condition of the HP system is guaranteed.

- Development of a high-performance water separator including sensor system Volkswagen/Audi. Use after proof of effectiveness and renewed damage analysis.

- Set up various series of tests with fuel containing water in the vehicle and components.

Steering committee VW 08.12.09

Strainer in front of intake valve

SECTION CONFIDETIAL

→ VW requirement: ≤2 particles(200-400µm) in residual particle test

→ Requirement cannot be met with clean practices at present

→ RB recommendation: Introduction of sieve in front of intake valve

- Possible SOP: 04.2010

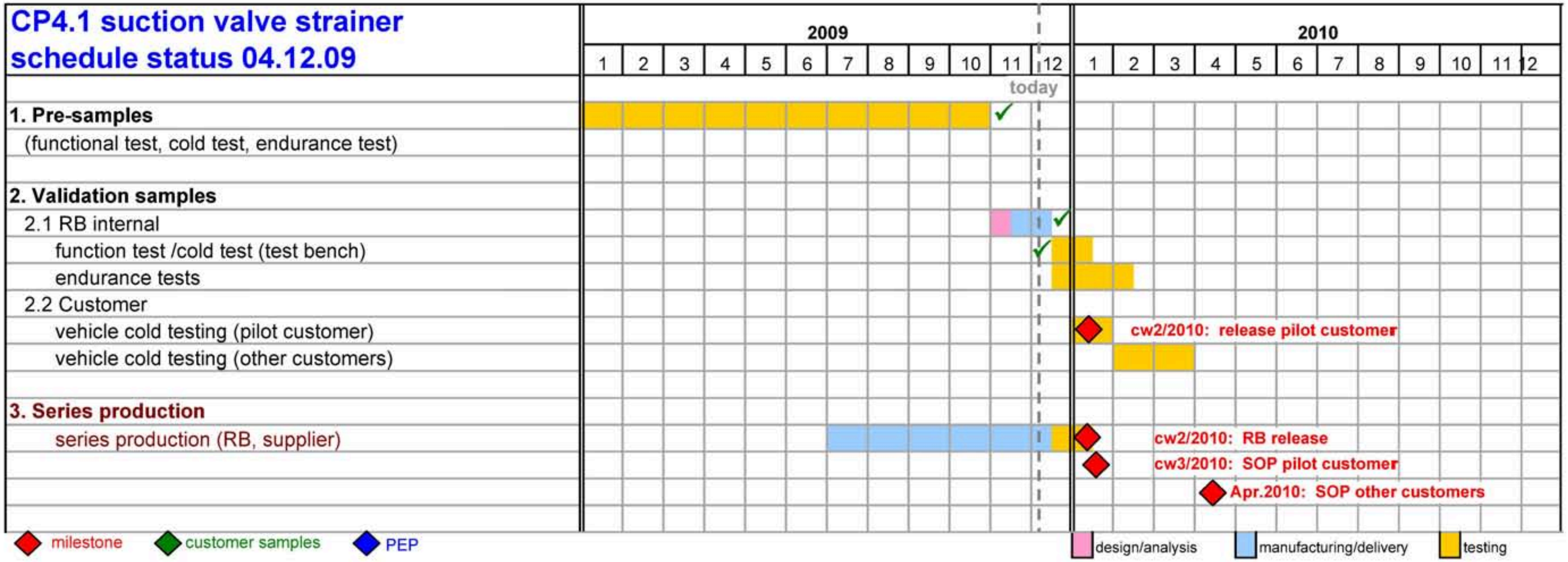
→ Intake valve strainer for pilot customers tested, SOP: 01.2010

Proposal for further procedure:

→ Delivery of 2-4 pump samples with intake valve strainers	| RB
→ Vehicle cold climate tests in climatic chamber	VW
→ Validation in winter tests	VW

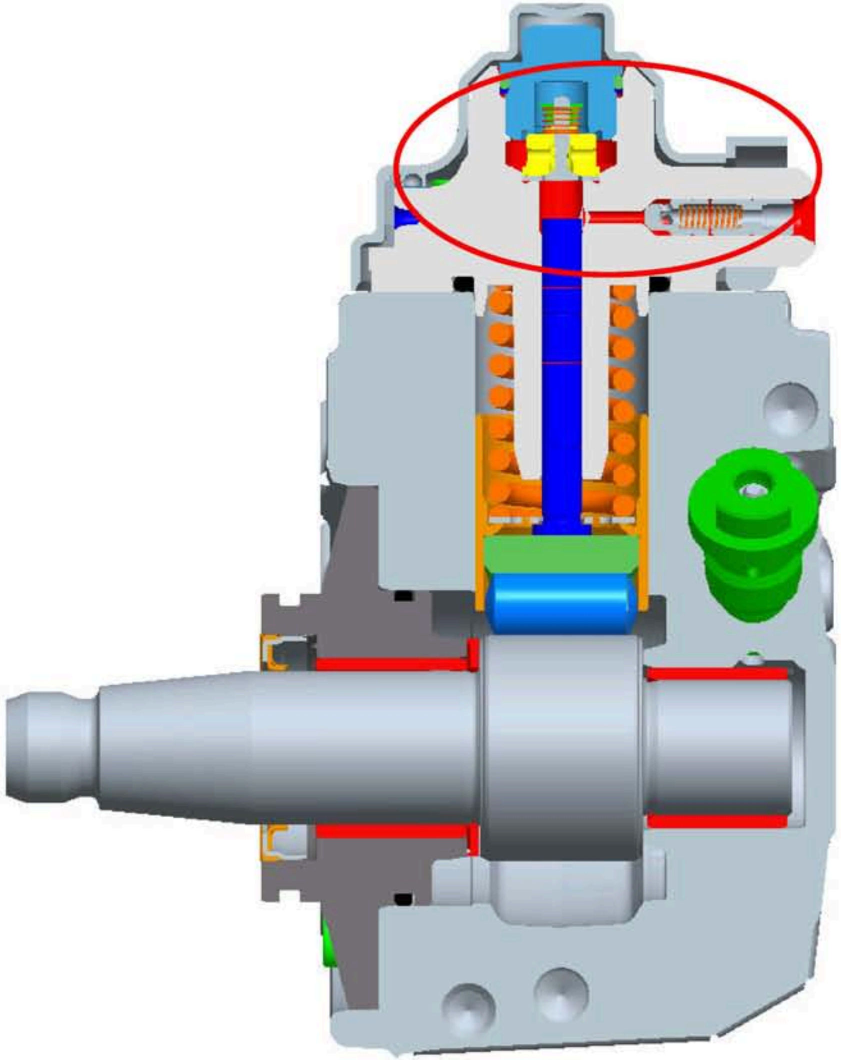
BOSCH

Steering committee VW 08.12.09



BOSCH

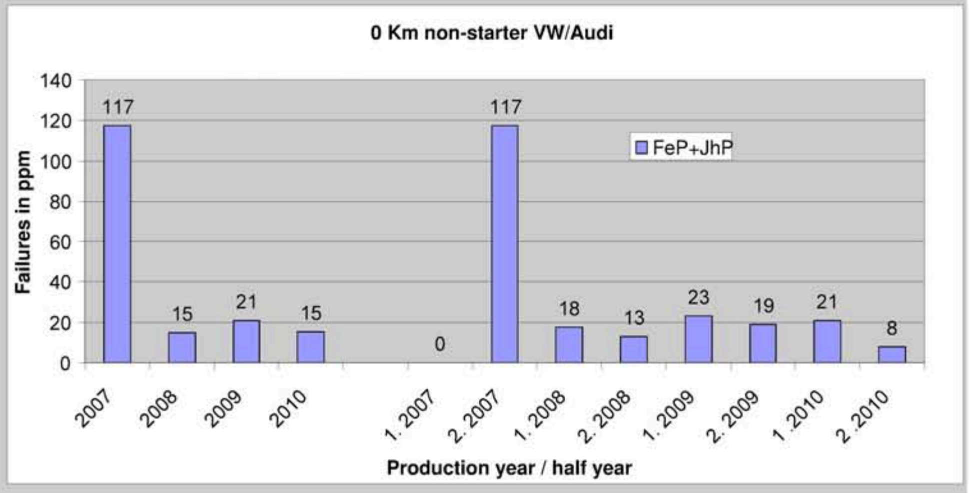
Status Problems / Measures for CP 4.1 (4-cylinder)
Cleanliness Concept CP4.1



Status Problems / Measures for CP 4.1 (4-cylinder)
Cleanliness Concept CP4.1: **Summary**

Problem 0 km nonstarters

Cause Particles from pump jam non-return or intake valve
=> no pressure build-up when starting



Status 15 ppm 0km non-starter with CP4.1

Measures

- Continuous improvement through the identification of particle sources in the process chain (splinters map) and the measures derived from this — In progress
- Introduction of intake valve sieve for USA pumps — WK 43/2010 done
- Optimization of met ring unit sieve to prevent particle bypass — 12.2010
- Development and evaluation of an optimized purging concept. Subsequent decision on the introduction of purging or comprehensive introduction of intake valve sieve. — To be introduced in series by end of March 2011
- Increased cleanliness requirements of new VW standard to be met by end of March 2011 Derogation for CP4.1 will be extended to end of March 2011

Status Problems / Measures for CP 4.1 (4-cylinder) Cleanliness
Concept CP4.1: **Cleanliness strategy (splinter map)**

Splinter map

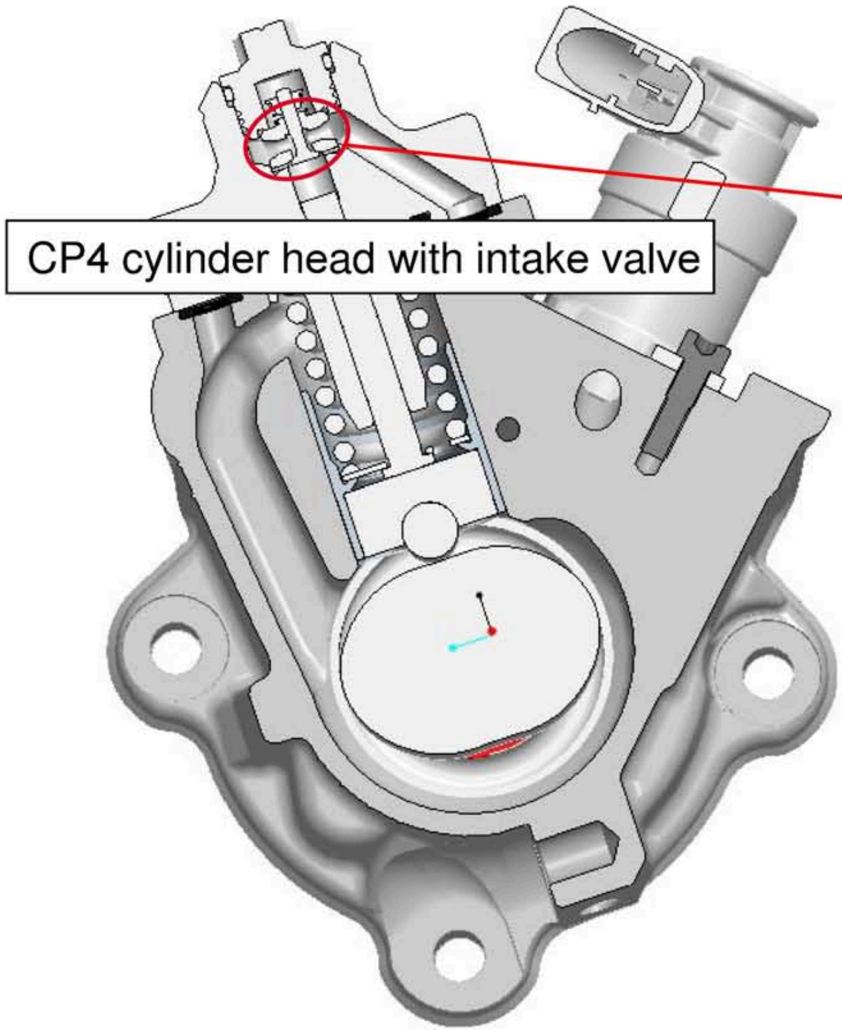
Input
- Internal failures
- External failures
- Particle tables/ visual check
- Analysis of residual impurities
  - -Product
  - - Inhouse production
  - - Bought-in part
- Daily process confirmation
- Workshops

Analysis
- EDX / optical analysis
- cf. material database CP4 and particle database
- Paretos / diagrams
- On-site observation
- Trials
- Evaluation of filter

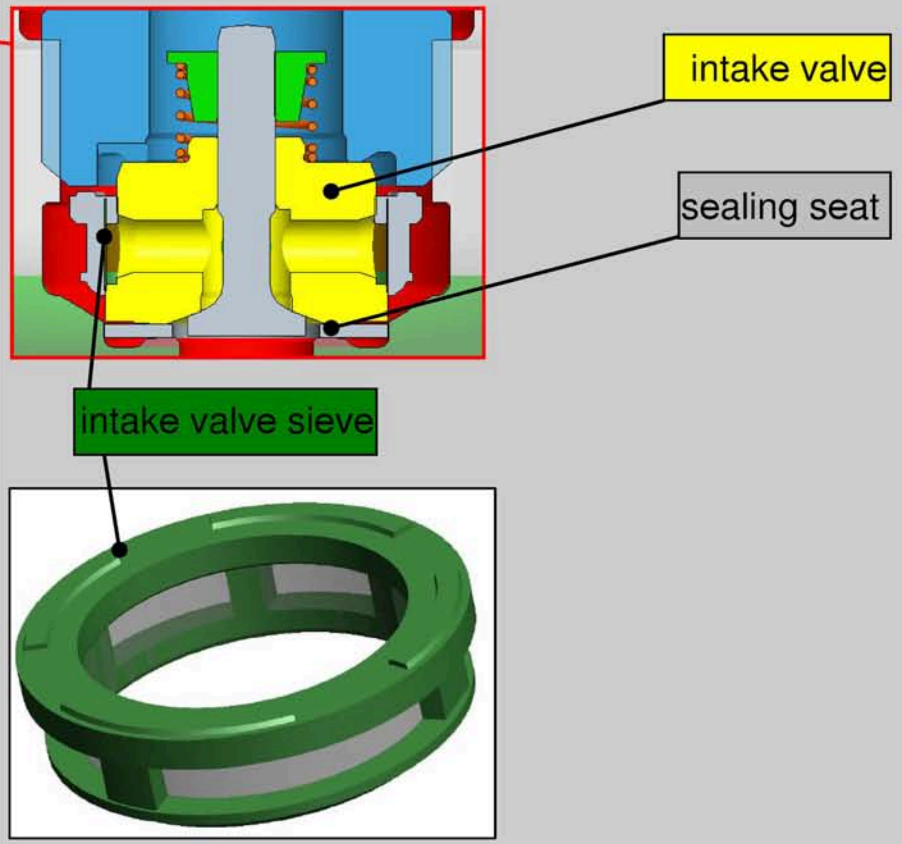
Measures
- Design improvement
- Targeted improvement of production and assembly processes
- Targeted improvement of cleaning processes
- Creation ofprioritized OPLs / PDCAs / Ishikawa
- Weekly followups with responsible persons

Objective
0 particle-related customer failures

Status Problems / Measures for CP 4.1 (4-cylinder)
Cleanliness Concept CP4.1: **Intake valve sieve measure**

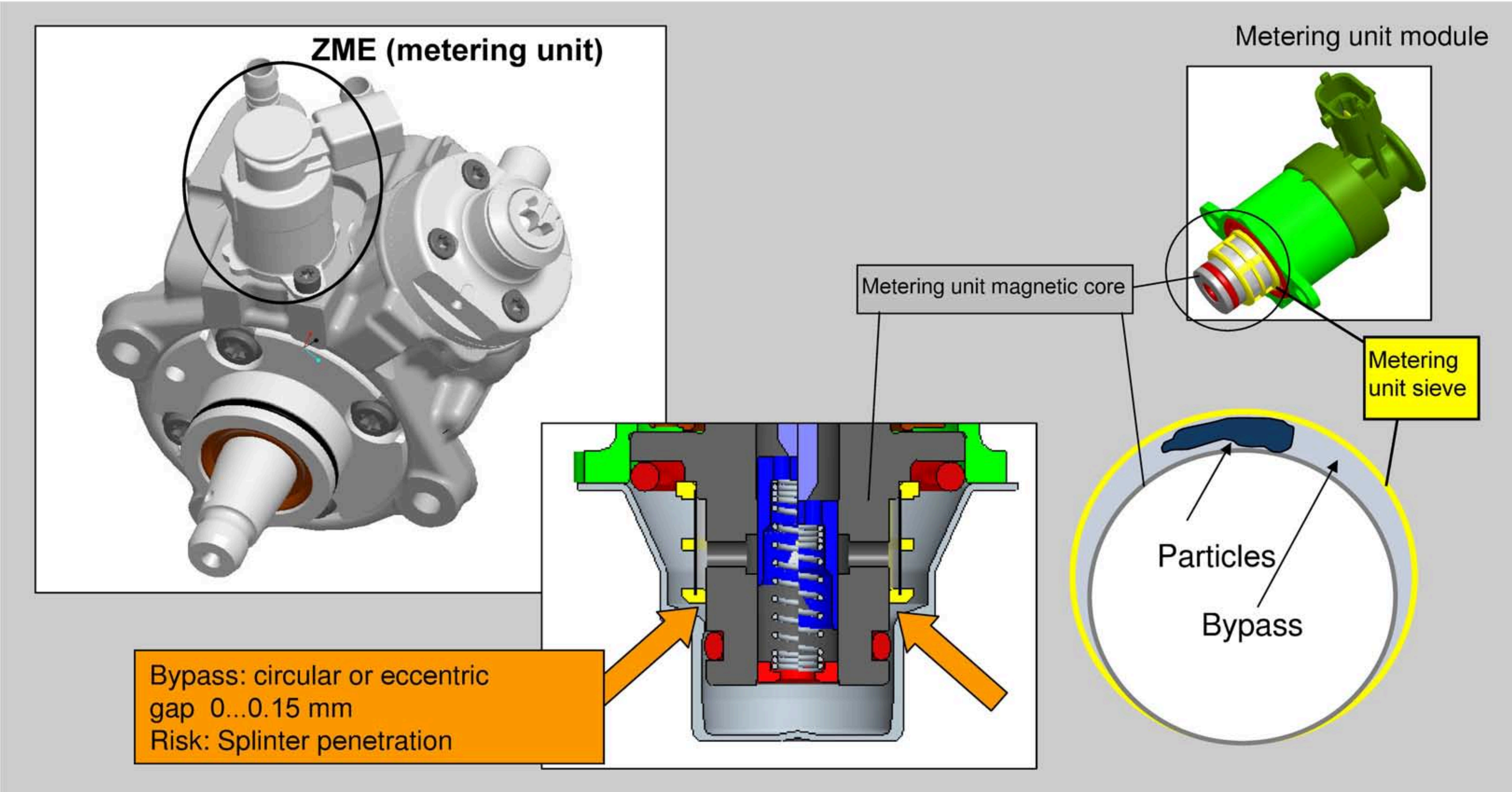


Introduction of an additional sieve to prevent the particle from entering the intake valve seal seat or the high-pressure area



Status Problems / Measures for CP 4.1 (4-cylinder)

Cleanliness Concept CP4.1: **Optimization measure for metering unit sieve**



CP4 - Field Failure USA with 5649m – QTS: 3833800

Pump type:	0 445 010 613 / 059 130 755 BC
IQIS:	230003103863
QMM32:	No. 4A970
Pump DoM:	4/26/2010
Ser. no.:	04-0452
Failure reason:	Mechanical fault, Deformed, damaged (as per. customer description)

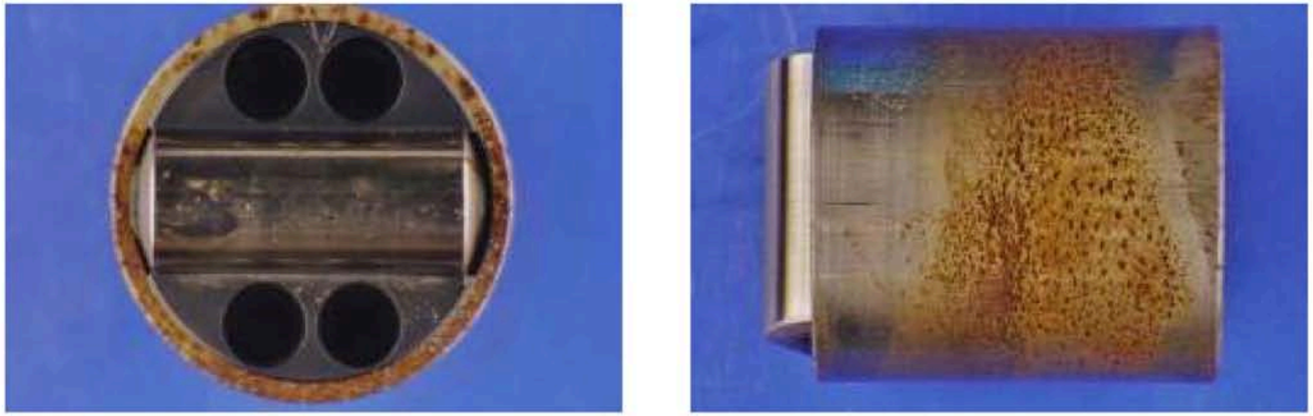
Results of analysis Standard finding:

-Packaging OK, protective caps missing, approx. 5 ml fuel sample taken,

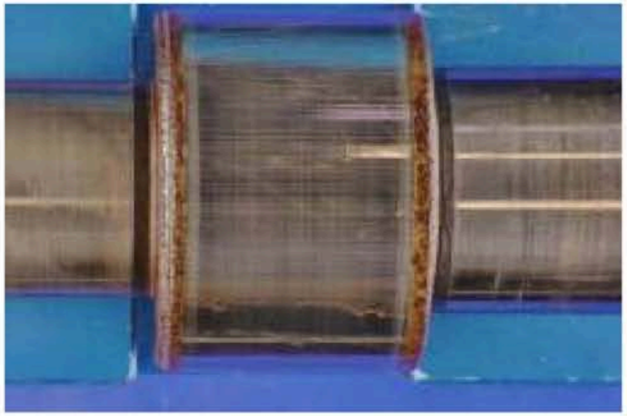
- onward and return flow supports visual check OK,
- NRV spring holders offset OK, NRV springs visual check R and L OK,
- deposit at NRV spring holders R and L
- Bubble Test OK,
- NoWe spin test OK,
- metering unit screws torque OK, deposit at metering unit adjustment disc,
- Functional test not OK. -> no excess current quantity,
- Overflow valve (OV) torque OK -> OV dismantled -> OV pistons jammed, OV with deposits,
- pump screw connections torque OK -> Pump dismantled:
- Vacuum test CH R and L OK,
- Deposit at pump parts, see pictures

BOSCH

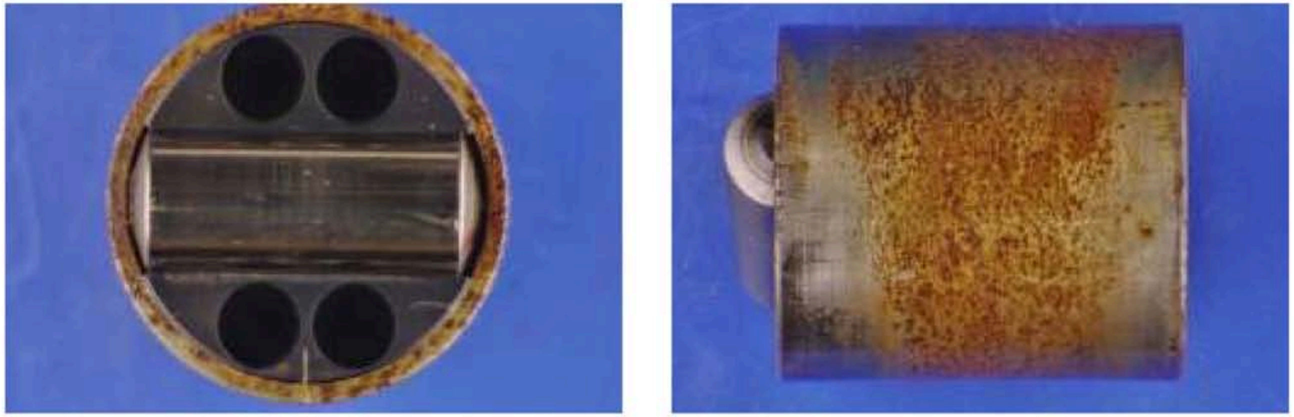
CP4 field failure USA with 5649 m



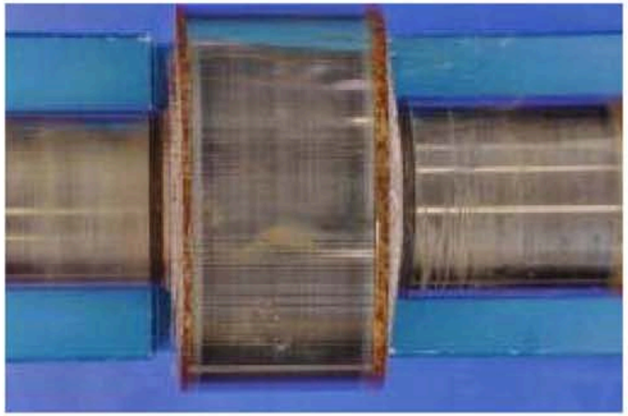
Roller plunger, right



Camshaft, BDC



Roller plunger, left



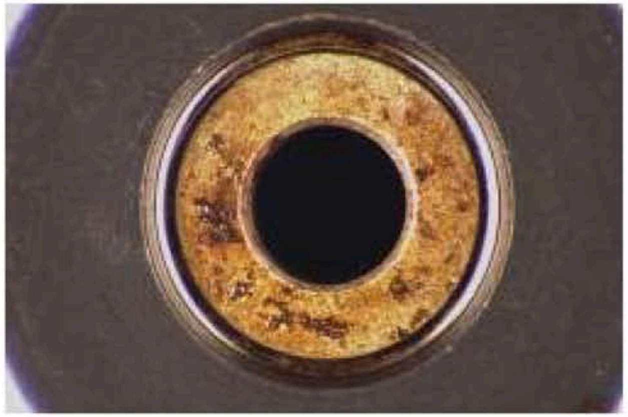
Camshaft, GP

CP4 field failure USA with 5649 m

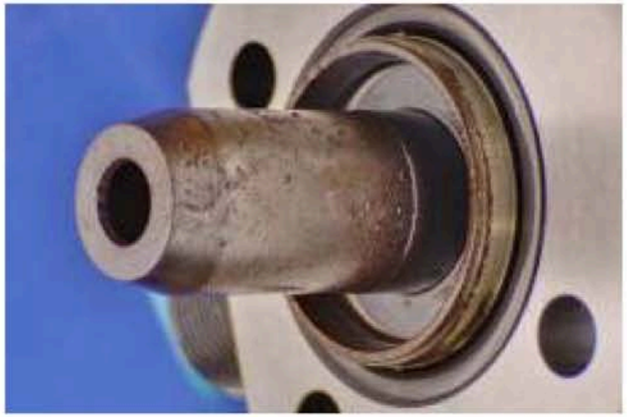
Excess current piston, strainer-side

Excess current piston, lock-side

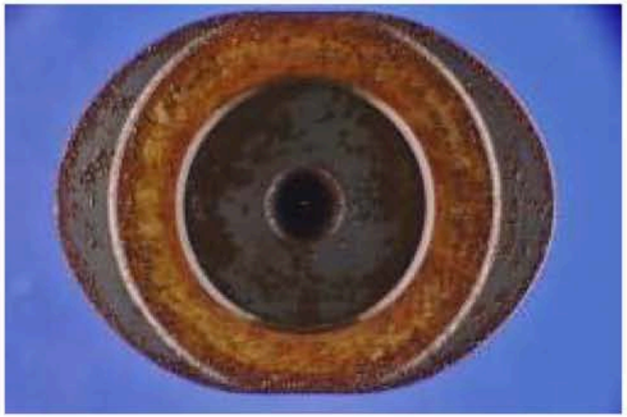
Excess current piston



Metering unit adjustment disc



Cylinder head, left, housing-side



Camshaft, housing bearing axial

BOSCH

Audi
Vorsprung durch Technik

APS on 8/22/11

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APS on 8/22/11

Situation CW33/11

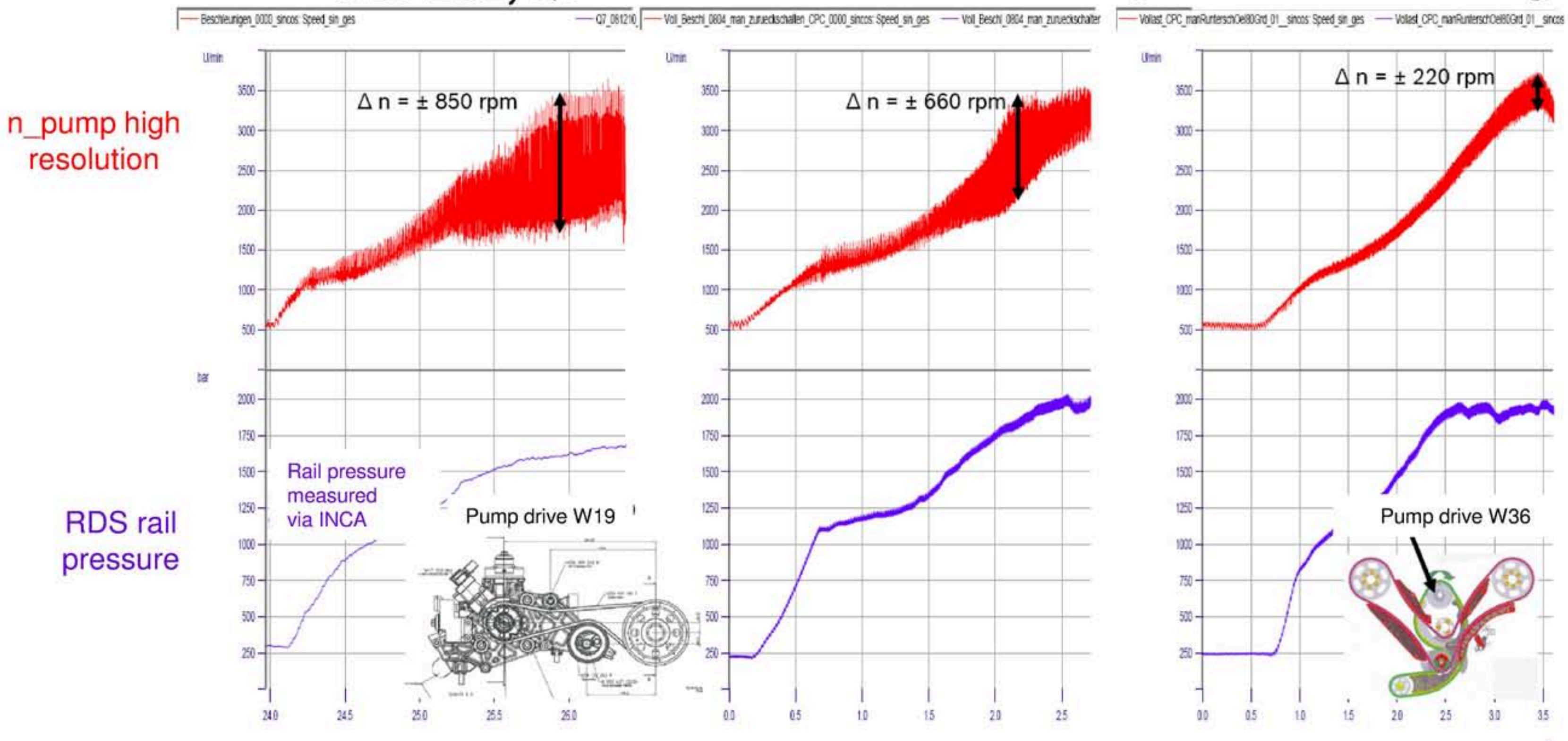
- **Field action HPP rebuild to anti-wear package 2 underway**
  - [redacted] stopped after 500 of 5,300 vehicles
  - [redacted] 18,000 of 27,000 have been reequipped
  - [redacted] 2,100 of 4,100 have been reequipped
  - [redacted] 1,000 of 1,500 have been reequipped
- **Findings from CP4 Task Force Bosch-Audi are more comprehensive than late 2010**
  - Failures / speed fluctuations Gen.1 engine >> Gen.2 and competition
  - Tension roller Gen.1 EU6 engine provides significant improvement
  - Correct position crankshaft/camshaft OP to HPP OP extremely important / toothed belt setting (partially omitted in CD – see Russia trip task force)
- **Recommendation** → see last 2 pages

APS on 8/22/11

Speed fluctuations V6-TDI engines

Full load acceleration

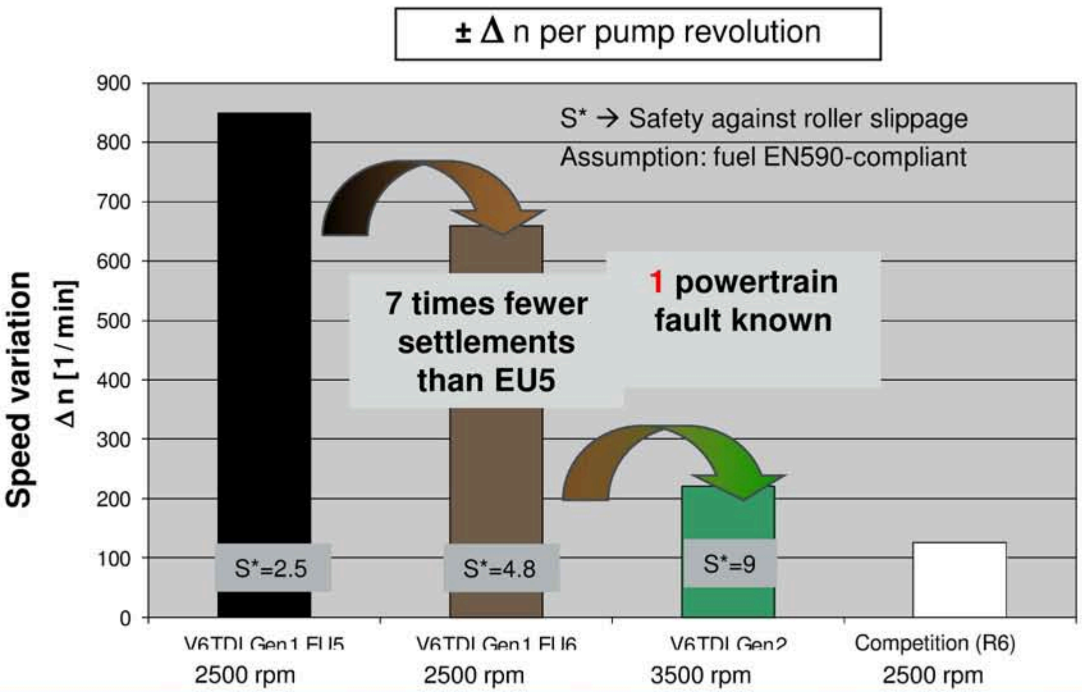
W19 EU5, Q7 | W19 BIN5/EU6 Touareg | W36 EU5 Touareg



Note: Engine speed signal evaluation method is the same for all engine variants.

APS on 8/22/11

- High speed fluctuations when starting up the high-pressure fuel pump result in high rotations of the roller in operation.
- Major speed changes in operation of the roller have an impact on the hydrodynamic lubricant layer between roller and roller contact. → Torsional vibrations are an amplification factor for powertrain damage.



<u>Q7 V6TDI Gen1 **EU5**</u>

- 4294 sold cars
- 12 settlements in MIS12

<u>Q7 V6TDI Gen1 **EU6**</u>

- 2234 sold cars
- 1 settlement in MIS12

→ **EU6 only 1/7 of settlements of EU5**

Evaluation period / country:

FD ZP8: 06/2009 to 06/2010

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Improvement from Gen1 EU5 to Gen1 EU6/Bin5 is achieved through different HPP belt tensioner.

V6TDI Gen2 with chain instead of belt drive for high-pressure fuel pump shows another further improvement of drive vibrations. 1 Gen2 powertrain fault known

APS on 8/22/11

AQUA rating HPP failures EU5 / EU6 [redacted] and U.S.

Engine	Market	Sold	Random sample MY10+11	Rand. sample MY10	Rand. sample MY11	Failures to 12 MIS MY10 + 11	MY10 12 MIS	MY11 9 MIS
EU6 / Gen.1	[redacted]	528	274	140	134	0	0	0
EU5 / Gen.1		14,813	9,483	5,700	3,783	59+6 units	1.06%	0.37%
EU6 / Gen.1		232	104	66	38	0	0	0
EU5 / Gen.1		2,046	1,411	822	589	5 + 0 units	0.61%	0
BIN5 / Gen.1		7,844	5,816	2,151	3,665	16+5 units	0.74%	0.40%

<u>Summary</u>: In [redacted], of 274 EU6 vehicles in the random sample, <u>none</u> has failed so far!

If we compare this with the EU5 failures in [redacted] (MY10 + MY11), the same failure rates in MY10 would equal 1-2 failures in MY10 0-1 failures in MY11.

In [redacted], of 104 EU6 vehicles in the random sample, <u>none</u> has failed so far!

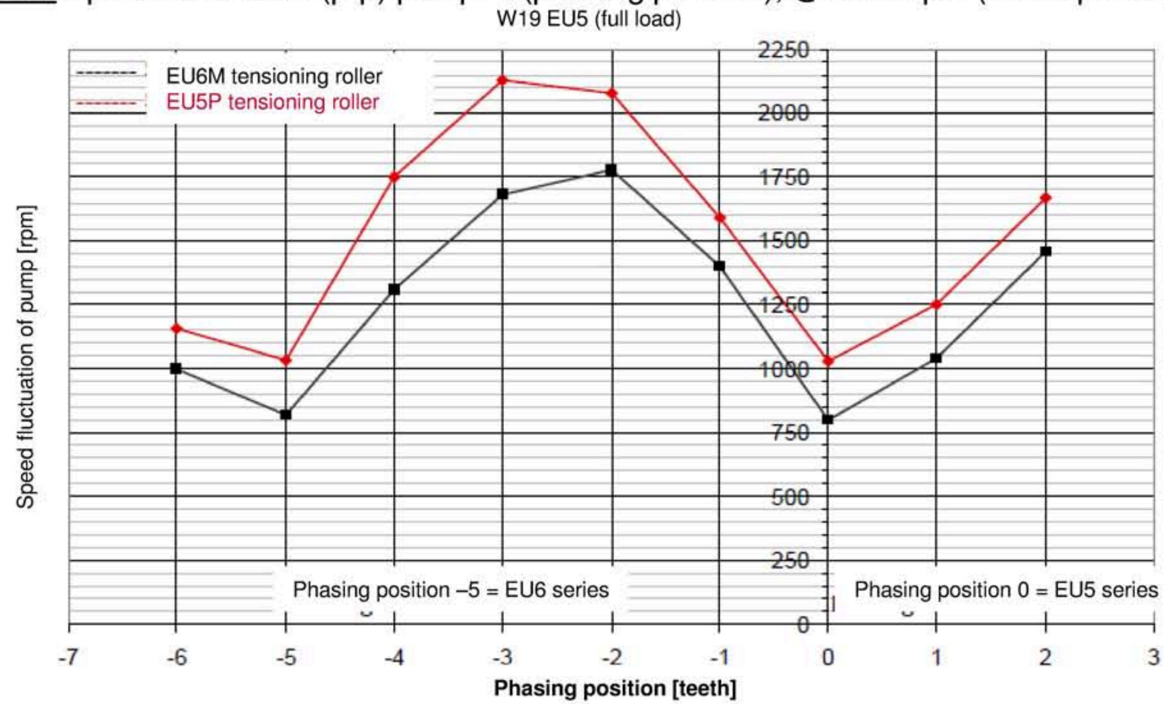
If we compare this with the EU5 failures in [redacted] (MY10 + MY11), the same failure rates in MY10 would equal 0-1 failures in MY10.

In the **U.S.**, with the standard "stronger" EU6 belt tensioners, there were approx. 30% fewer failures in MY10 than in [redacted], although the two fuel markets are not comparable.

APS on 8/22/11

Torsional vibration measurements @ Audi V6

Results: Speed fluctuation (p-p) pump =f (phasing position), @ 2440 rpm (3250 rpm engine)



Summary:

. EU 6 tensioning roller in the center leads to approx. 250 rpm less rotation speed oscillations on the pump

. Setup position 0 or minus 5 teeth found to be best variant

. Misorientation of the pump at pump change leads to a stronger increase of torsional vibrations under certain conditions.

APS on 8/22/11

Speed variation of pump at approx. 3,300 rev/min engine or 2,500 U/min pump:

W19 with EU5 tension roller measured in **vehicle** / cold:1700 rev/min (2500 +/- 850)

W19 with EU5 tension roller measured in **vehicle** / hot: 1300 rev/min

W19 with EU6 tension roller measured in **vehicle** / cold:1320 rev/min (-22%)

W19 with EU6 tension roller measured in **vehicle** / hot: 1070 rev/min (-18%)

W36 with chain drive: 440 rev/min

W19 with EU5 tension roller measured on **engine**: 1040 rev/min

W19 with EU6 tension roller measured on **engine**: 800 rev/min (-23%)

W19 with EU5-SR – 3 teeth shifted on **engine**: 2150 rev/min (>> +100%)

W19 with EU6-SR – 2 teeth shifted on **engine**: 1770 rev/min (>> +100%)

- Measurements on **vehicle** show a similar effect, only approx. +/- 300; max. ca. 2100 rev/min
- Strong temperature influence, that is, cold engine is more critical than hot

APS on 8/22/11

Recommendation [redacted]

- **Series production**

- Conversion of Gen.1 series to Euro 6 tension roller (B8/Q5 not PA; VW D1) underway
→ additional costs of [redacted] are being negotiated

- **Normal damage case / repair case in CS**

- Installation of stronger belt tensioners for Gen.1 EU5

- Optimization of TPI and repair guide for belt tensioner, installation of HPP / toothed belt, pre-fueling and tank content in coordination with [redacted]

- **OP system**

- Introduction of a "red note" in the HPP packaging with important information regarding pump replacement (installation of HPP / toothed belt, fuel prefilling, tank contents) in standard CS languages [redacted]
English, [redacted]

APS on 8/22/11

Recommendation Non-responsive content removed

- **Field action 23G7** Non-responsive content removed

1.All vehicles that have not been touched yet, should be converted with changed instructions (**change belt tensioner**, **clear note on HPP OP conversion**)

2.Sample inspection on > 25 vehicles per market with executed 23G7 action to see whether setting of HPP OP is correct

3.Sample inspection on > 25 mass-produced engines to see whether setting of HPP OP is OK; vehicle GS-2 was configured 180° incorrectly (note: check of CS position position not described in guidelines until 2011)

4.Depending on failure rate, "wrong position HPP OP" market-specific

- Failure < 1-3% → no action
- Failure > 1-3% → Carry out new action (see item 5)

5.New action to check crankshaft/camshaft/HPP OP (only vehicles with old instructions) and if not OK,

- install stronger belt tensioner and configure HPP OP <u>or</u>
- (only configure HPP OT)

- **Vehicles outside field action 23G7** Non-responsive content removed
  - Do not carry out any activities / optimized repair in case of damage (see Page 8).

EA11003EN-01536[0]

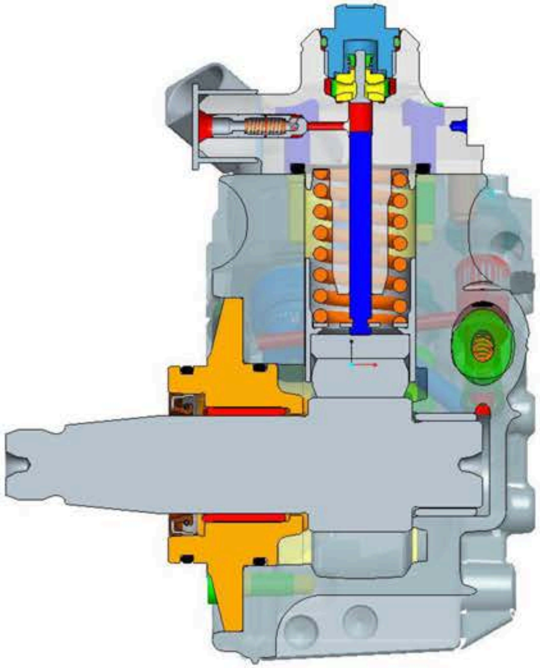
CP4 - Robust Flange 2009.051, 2009.052

Presentation	Date
First presentation	11/26/2009
1st follow-up	6/8/2010
2nd follow-up	6/15/2010

1. Change number

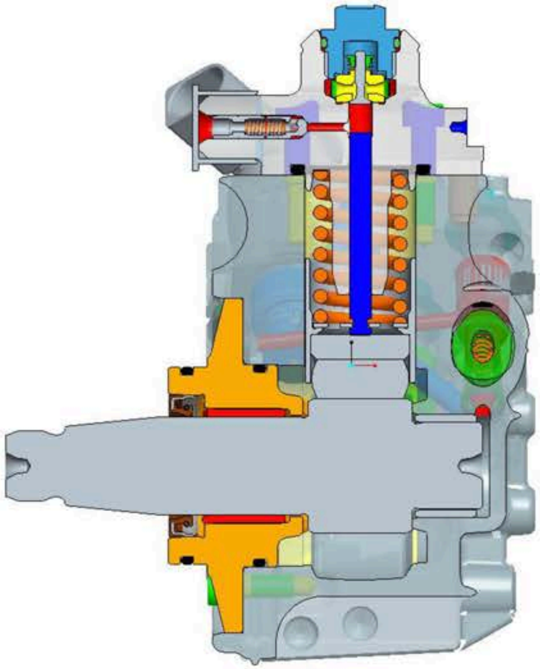
DS-002 045 748
DS-002 044 074

2. Product CP4



	Bosch no.	Customer no.
New product releases for		
Audi	0 445 010 611	059 130 755 BB
Audi	0 445 010 613	059 130 755 BC
Audi	0 445 010 631	059 130 755 AN
Audi	0 445 010 632	059 130 755 AK
Change slips [n.n.] for		
Audi	0 445 010 619	05A 130 755 C
Audi	0 445 010 620	057 130 755 AD
Audi	0 445 010 624	057 130 755 AC

CP4 - Robust Flange 2009.051, 2009.052



	Bosch no.	Customer no.
Change slip DS-002045748 for		
VW	0 445 010 507	03L 130 755
VW	0 445 010 514	03L 130 755 D
VW	0 445 010 526	03L 130 755 L
VW	0 445 010 529	03L 130 755 AC
VW	0 445 010 5xx	03L 130 755 AA
Change slips [n.n.] for		
VW	0 445 010 508	03L 130 755 A
VW	0 445 010 520	03L 130 755 J
VW	0 445 010 523	03L 130 755 F
VW	0 445 010 527	03L 130 755 M
VW	0 445 010 5xx	03L 130 755 AB

CP4 - Robust Flange 2009.051, 2009.052

3. Description Introduction of robust flange

3.1 Reason Increase robustness for Q improvement, improved pump performance (CP4 for 2200/2500bar) require new centering concept. This robustness increase is to be transferred to all CP4s (new standard). Measure to achieve the agreed series prices

3.2 Customer advantage, benefit Increased robustness

4. Details: Overview of changes

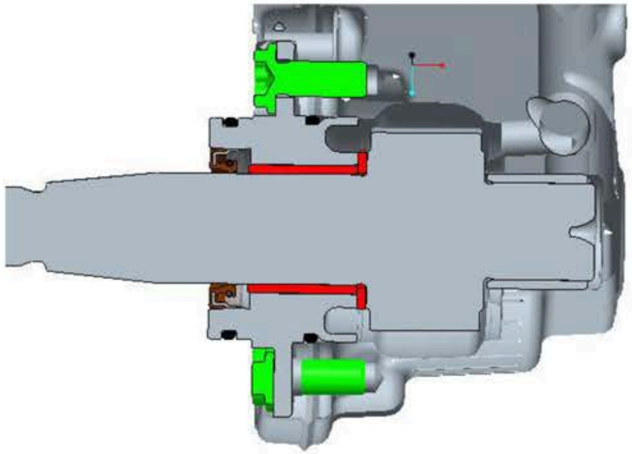
4.1 Press assembly in screw level

4.2 Screw connection

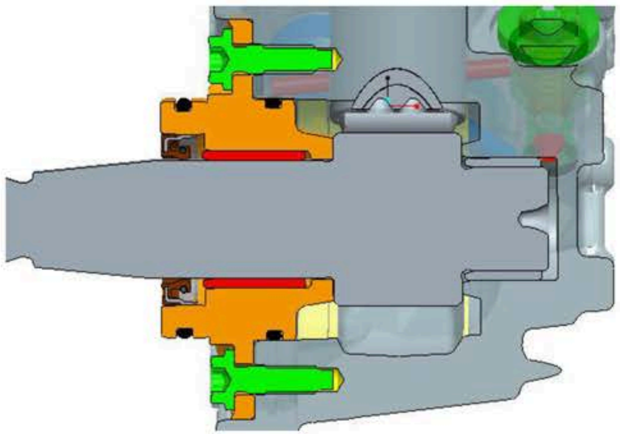
4.3 Cam support surface

4.4 Bushing

Series flange

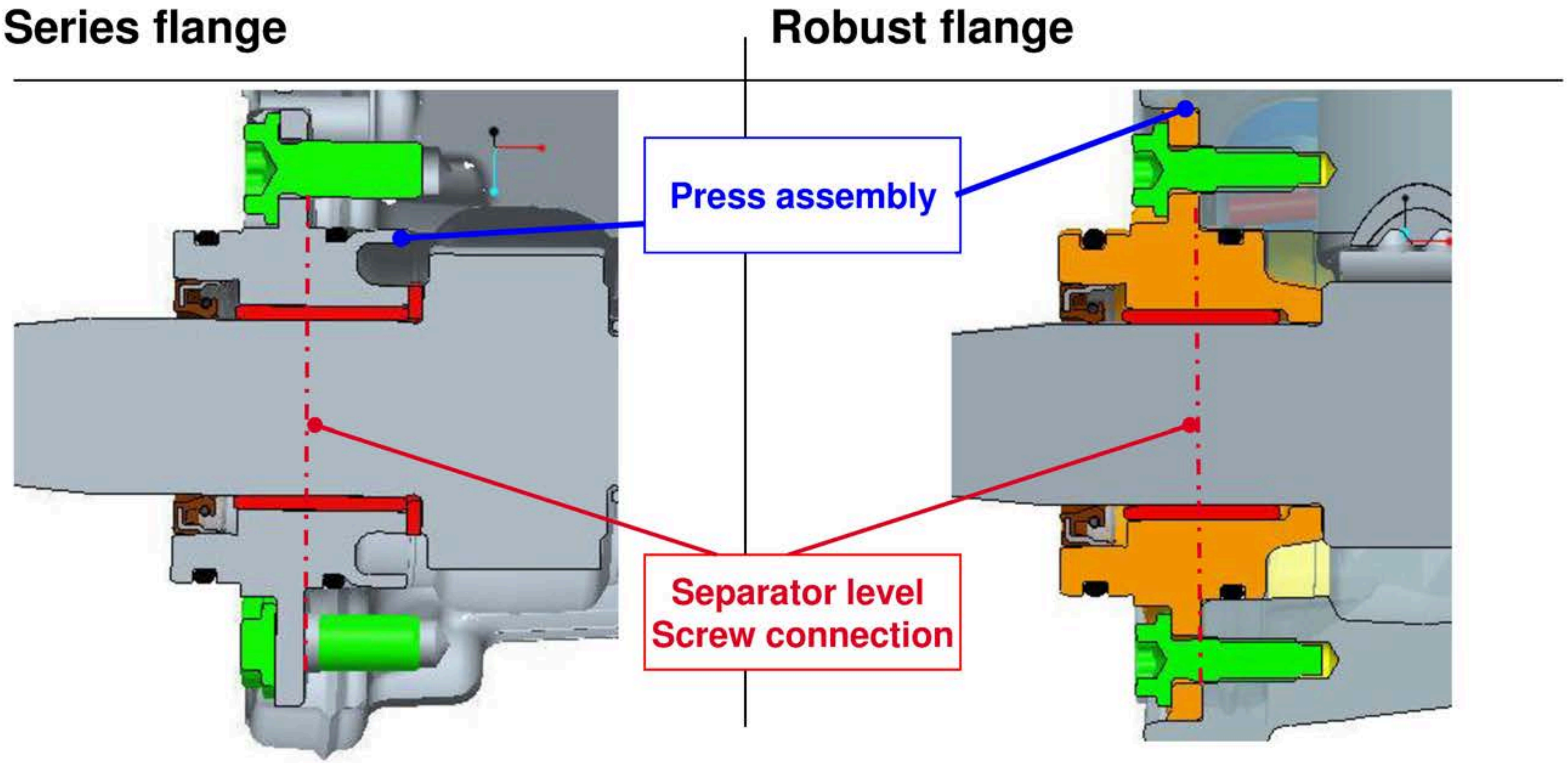


Robust flange



CP4 - Robust Flange 2009.051, 2009.052

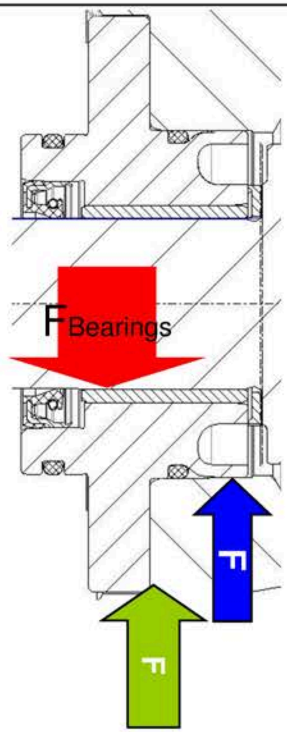
4.1 Press assembly in screw level



Press assembly to support lateral forces moved to outside to separator level of flange/housing components

CP4 - Robust Flange 2009.051, 2009.052

Series flange



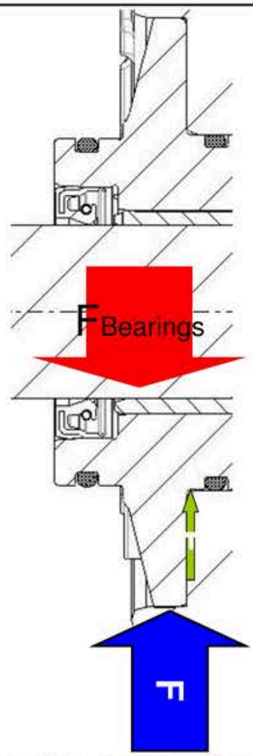
Support for lateral forces through

a) Press assembly "internal" force flow through thin-walled groove (notch radius)

Share: ~40%

b) Friction coefficient of screw connector
Share:~ 60%

Robust flange



Support for lateral forces through

a) Press assembly outside at force level

Share: ~90%

b) Friction coefficient of screw connector

Share ~10%

- Direct support for lateral forces through press assembly, moving proportional force
- Reduction of assembly tension due to thin-walled groove and notch radius
- Greater pressing area due to larger diameter of press assembly

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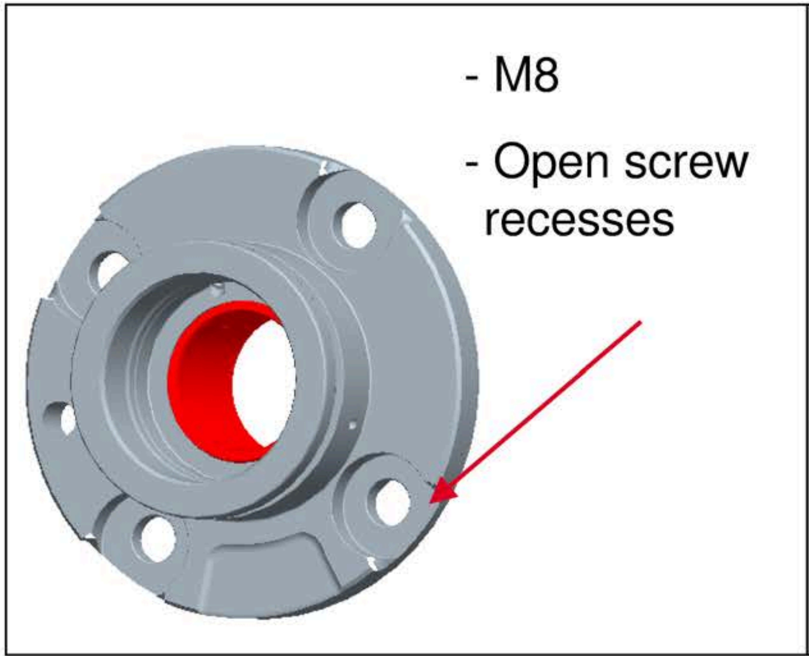
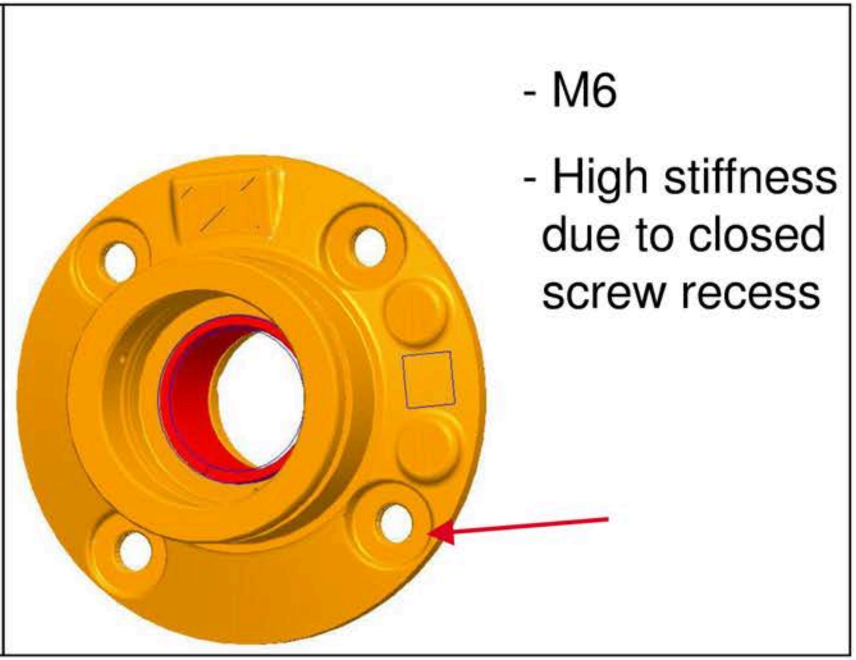
CP4 - Robust Flange 2009.051, 2009.052

4.2 Screw connection

Series flange



Robust flange



- Reduction of screw factor possible through changed distribution of force absorption

- Burr formation reduced (CP4 cleanliness initiative)

- Increased stiffness of press assembly through closed screw recesses

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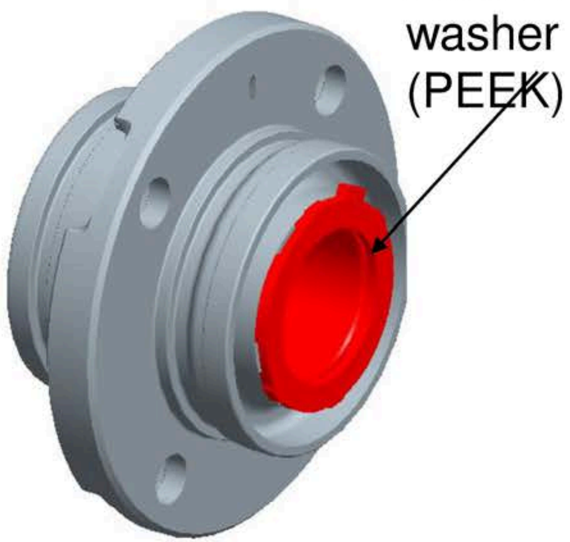
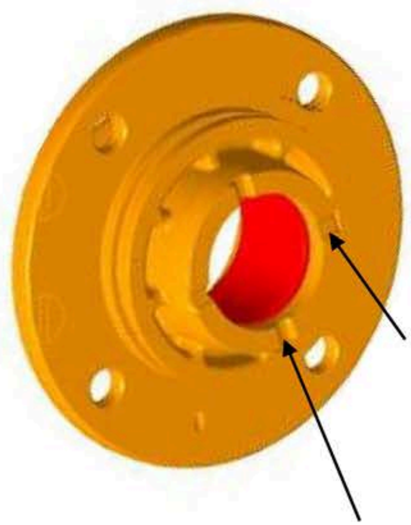
CP4 - Robust Flange 2009.051, 2009.052

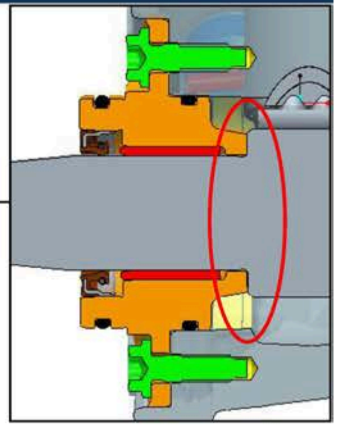
4.3 Cam support surface: Material

Series flange	**Robust flange**





(Si content: 12.0 – 12.8%)

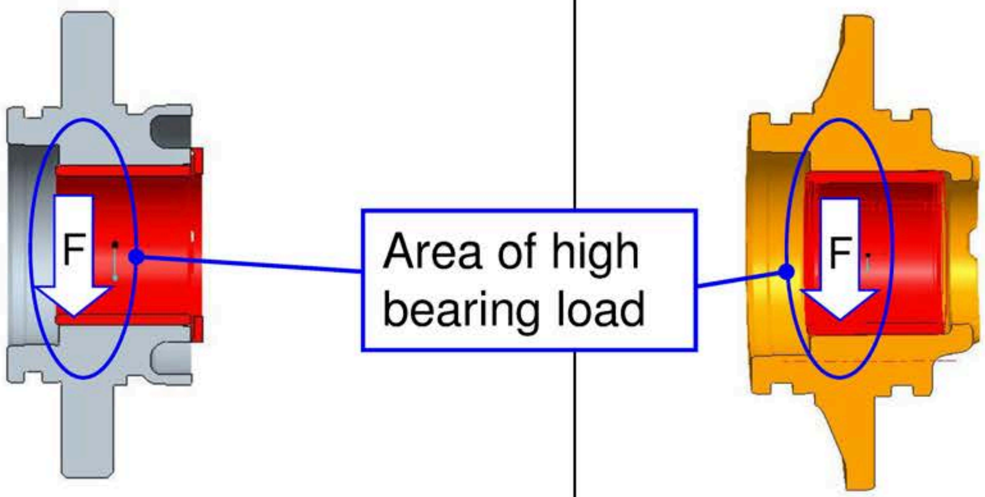


BOSCH

CP4 - Robust Flange 2009.051, 2009.052

4.4 Bushing

Series flange	**Robust flange**
Force transmission series	= Force transmission of robust flange



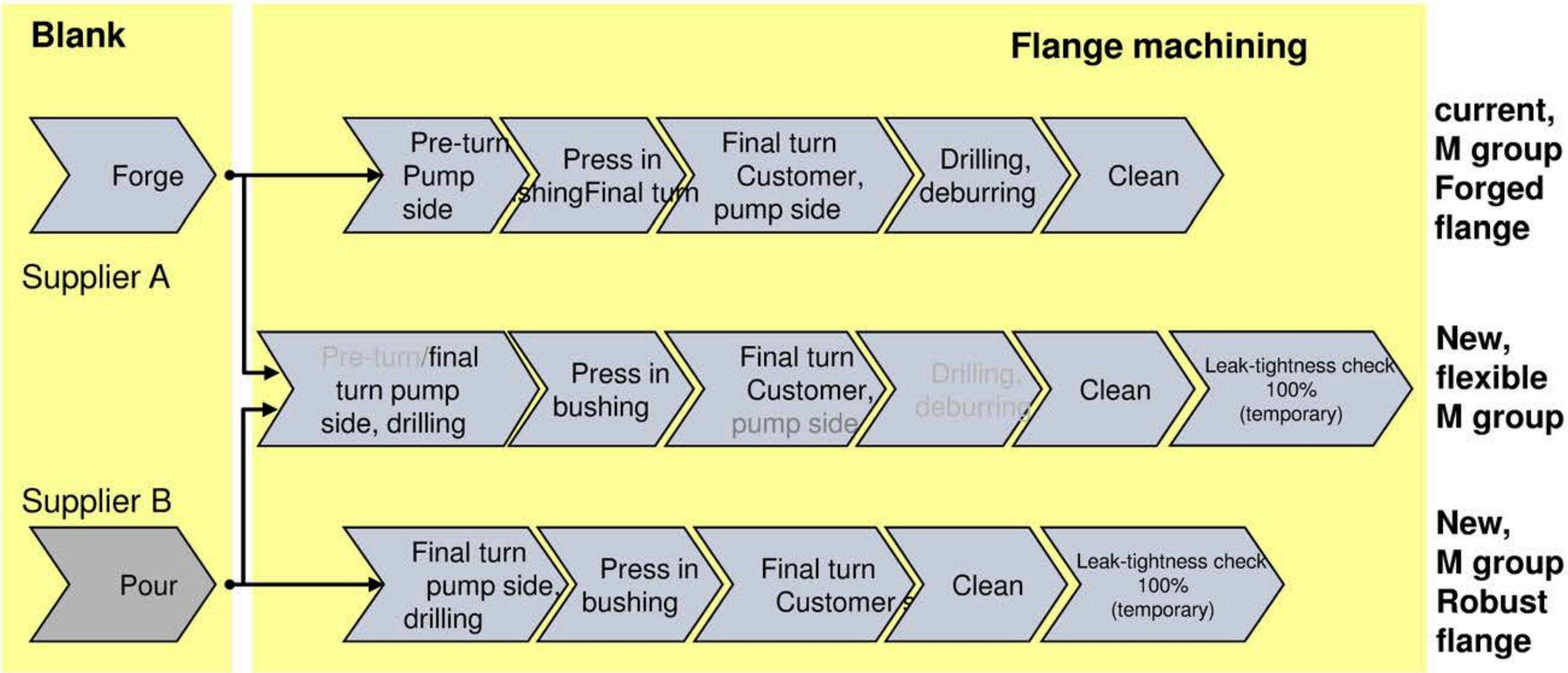
Bearing length 22.9 mm	Bearing length 18.3 mm

Force transmission through customer drivetrain dominant, bearing largely loaded on customer side, supporting bearing length unchanged

CP4 - Robust Flange 2009.051, 2009.052

4.5 Process chain

- Blank: New production process and supplier
- Flange machining: Flange redesign requires modification of production process



5. Bosch validation

5.0 Tests

- Extreme pressure tests bushing radial	Done	☺
- Extreme pressure tests support surface axial	Done	☺
- Press-in test flange	Done	☺
- Screw test flange	Done	☺

5.1 Function

- Exite bearing simulations	Done	☺

5.2 Flange blank (I/II)

Material tests	Done	☺
P-FMEA	Done	☺
No. RPZ > 125	4	

→ Assessment of possible faults:
- Porosity
- Crack formation

<u>Protective measures:</u>

1.) 100% leak test for finished product

2.) 100% pressure loss test after "Flange machining". (temporary)

3.) In-process sampling (machining) at flange blank supplier

CP4 - Robust Flange 2009.051, 2009.052

5.2 Flange blank (II/II)

EMPB	Done	☺
Machining capability	Done	☺
2-day production	Done	☺
Process audit	Done	☺
Degree of fulfillment. 86% (internal RB requirement: 85%)		
Post-audit (verify effectiveness of defined measures)	Open	

5.3 External purchase of flange bushing

No process change for released bushing SNR

[redacted] Done ☺

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CP4 - Robust Flange 2009.051, 2009.052

5.4 Screw

[redacted] Non-responsive content removed

Process audit (result: 91%) Done

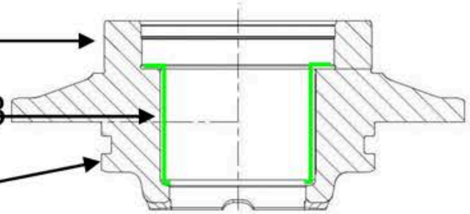
5.5 Flange machining with pressed-in bushing

P-FMEA "Robust flange"	Done	
No. RPZ > 125	None	
Machining capability	Done	
Internal 2-day production	Done	
RB internal release	06/2010	

Customer fit-in Cmk: 2.7

Bushing roundness Cmk: 2.3

Pump fit-in Cmk: 2.3

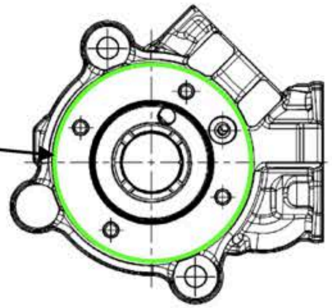


CP4 - Robust Flange 2009.051, 2009.052

5.6 Housing machining

P-FMEA "Housing"	Done
No. RPZ > 125	None
Machining capability	Done
RB internal release	06/2010

Flange fit-in Cmk: 2.3



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CP4 - Robust Flange 2009.051, 2009.052

5.7 Product assembly

P-FMEA "Product assembly"	Done
No. RPZ > 125	None
2-day production prod. assembly (press flange into housing + screw)	Done
RB internal [redacted] release	Done

BOSCH

5.8 Endurance / durability testing Bosch

5.8.1 Pre-trial

2 x 2000h Program CR	Done	☺
2 x 2000h Program CR	Done	☺
2 x 100h HFRR-QALT with GDK570	Done	☺
1 x 210h t-HALT at nominal pressure	Done	☺

5.8.2 Baseline validation

2x150h PER	Done	☺
2x2000h System PER	Done	☺
2x350T MSS 780h	Done	☺
1x350h n-HALT	Done	☺
1x3D Vibration	Done	☺

CP4 - Robust Flange 2009.051, 2009.052

5.8.3 Broad validation

4 x 2000h program CR with GDK 570	Done ☺
4 x 1000h constant CR with GDK 570	Done ☺
2 x 100h HFRR- QALT with GDK 650	Done ☺
2 x 150h p- HALT with GDK 570	Done ☺
1 x 3D Vibration test 500h	07/2010

CP4 - Robust Flange 2009.051, 2009.052

6. Customer validation:

VW 10 x 0 445 B21 116_13 in Wk 4
(2 x GDV, 1 x Veh. CR, 1 x engine CR)

AUDI 7 x 0 445 B20 252_06 in Wk6

1 returned to EHP so far:
- Motor CR (PZD+OVL) 892 h

7. Launch date **08/2010**

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Robust Flange – VW Engine Endurance Run

Status: 6/14/2010

Customer return VW R4 2.0L

➔ Pump:	0 445 B21 116-13 CP4.1XS-398-2x6-REC-3.3-1.95-MT4.2
➔ Flange version:	0 445 D20 AK6-00 Die-cast, Bushing w/o friction washer
➔ Continuous run. conditions:	Engine CR 892h, engine number 00000070 Audi C/ inline 125 KW EN 590, Exhaust standard EU5 LL n_nom = 4500 min-1, p_nom = 1800 bar
➔ Pump durability test	081–4672, VW R4 2.0 EU5 2010-CP4-0426 (DNA 3923)

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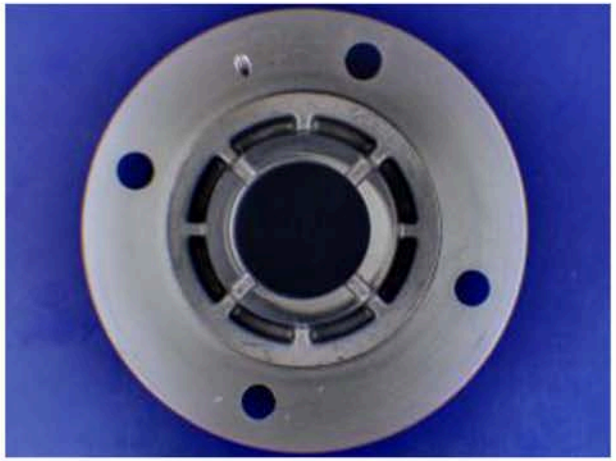
Robust Flange – VW Engine Endurance Run

Status: 6/14/2010



View of flange with axial support surface segments

View of flange with WDR

Pump:

081 – 4672

Runtime: 892h

Fct. OK

SB OK

Detailed view of axial support surface segments

Detailed view of support segment

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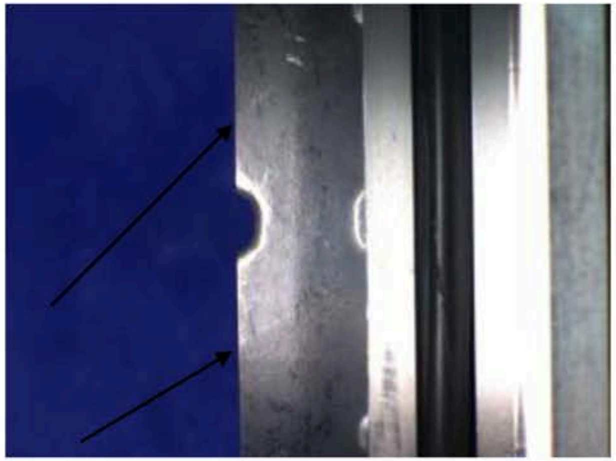
Robust Flange – VW Engine Endurance Run

Status: 6/14/2010

View of flange with bushing



View of flange segments on face

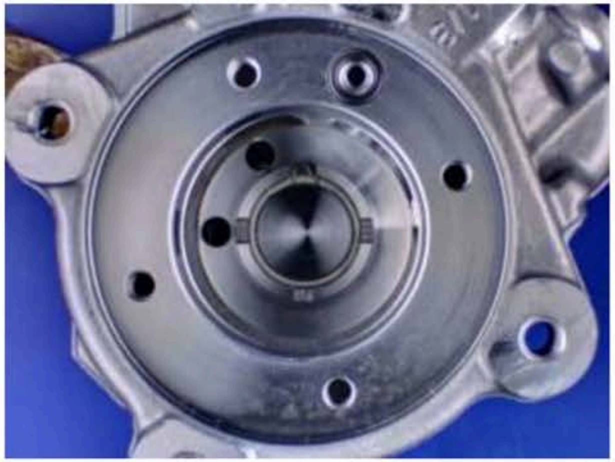
Pump:

081 – 4672

Runtime: 892h

Fct. OK

SB OK



Housing fit-in for robust flange

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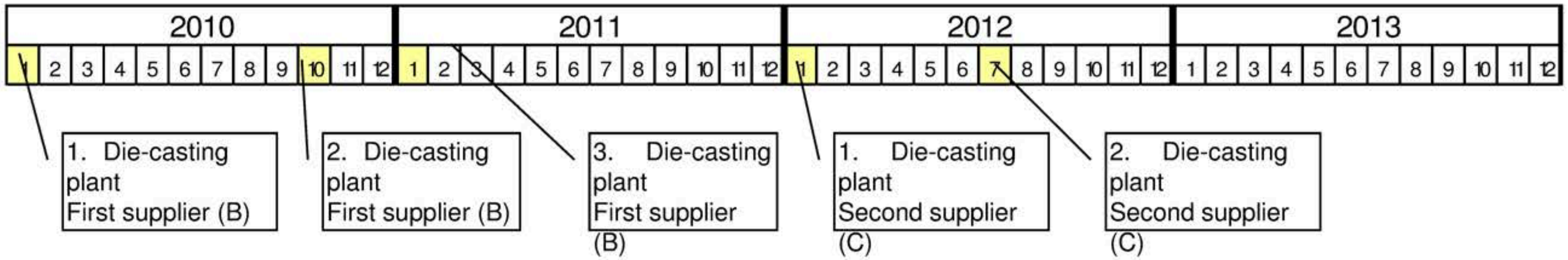
CP4 - Robust Flange 2009.051, 2009.052

8. Capacity management

8.1 Capacity expansion of blank

- Capacity expansion for first supplier (B)
- Second supplier from E/2011 (C)



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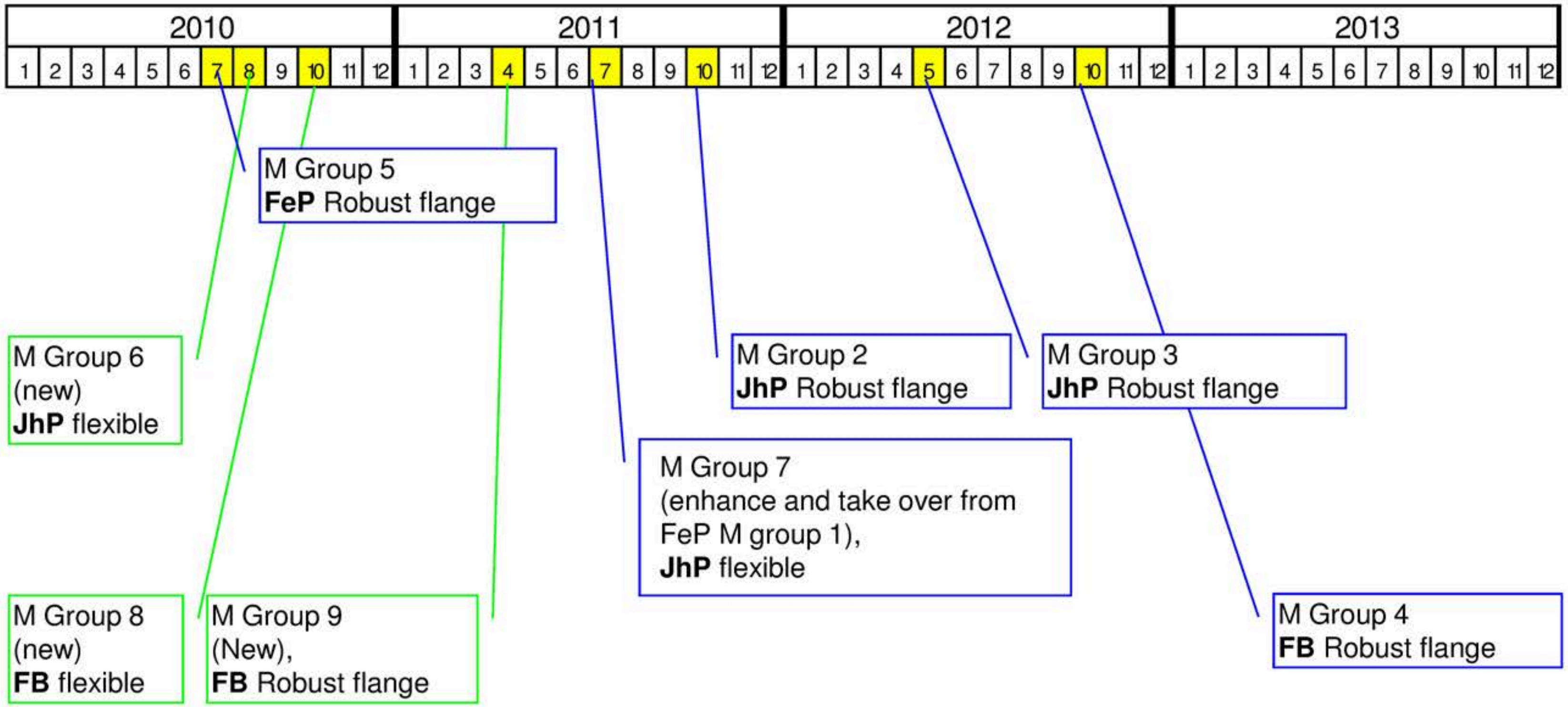
CP4 - Robust Flange 2009.051, 2009.052

8.2 Planned capacity expansion of flange machining



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CP4 - Robust Flange 2009.051, 2009.052

9. Risk: If the defined validation program is completed successfully, only a low implementation risk is expected.

10. Alternatives: ---

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CP4 - Robust Flange 2009.051, 2009.052

11. Customer approval:

Approval granted				
	Date	Department	Signature	Remark
VW				
Audi				

Open items / requirements	Responsible	Completion deadline

BOSCH

Status of the SV measures in KVS (design data management system)

- SW measures have been implemented for all VW vehicles (Touareg, Phaeton) with CP4.2-HDPs
  → Data protection at AUDI
  → Non-responsive content removed

- No CP4.2-HPPs are installed in other VW vehicles _ CP4.2 covered!

- In all VW vehicles with inline electric fuel pumps, this lies immediately before the CP4.1-HPP, considerably shorter pressure build-up times versus AUDI fuel supply (assessment complete)
  → short line, low volume for pressure build-up
  → Difference at AUDI: 5 x longer line and filter volumes

- Maintenance of the SW measures means a 100% doubling of the data volumes for all VW cars
  → Measures only implemented where required, e.g. NAR

- from [redacted] (WK10/2012) the SW package agreed between VW and AUDI which goes far beyond the measures agreed up to now (see Slides 2-8).

Software extensions EC-EKP

Overview:

1. Starting volume flow
2. Volume flow in the event of a stop and restart
3. Volume flow offset depending on the battery voltage
4. Negative recuperation recommendation
5. Start delay
6. Control with initialization (Kl15) and in the over-run
7. Control after terminal 15 off (pump over-run)

Software extensions EC-EKP

1. Starting volume flow

[redacted]/requirement:

- A higher fuel volume flow is needed at the start than supplied by the currently need-based control unit.
- The current Audi solution of applying this volume flow depending on the rotational speed has the disadvantage that the pump with the higher volume current is also controlled when the engine is switched off and no dependency on the temperature of the fuel is indicated.

Agreed solution:

- At the start (query start status which is set approx. 100ms before the starter is turned), an applicable volume flow is specified via an indicator field depending on the rotational speed and injection volume.
- The feeding of the increased volume flow when the engine is switched off is prevented as this would be audibly discernible.
- With an applicable delay time, the volume flow can also optionally be supplied after the engine start.
- Absolute value depending on the fuel temperature as a maximum selection.

2. Volume flow in the event of a stop and restart

Software extensions EC-EKP

Non-responsive content removed requirement:

- At high fuel temperatures, it can be necessary for the pump in the stop phase or when restarting from the stop phase to be operated at a specific volume flow.

- Only one constant volume flow is specified in the current software structure for the event of a stop and restart in each case.

Agreed solution:

- The volume flows should be determined depending on the temperature of the fuel.

- If the volume flow is applied at 0 l/h for low fuel temperatures, the supply can be shut off completely in the stop phase or when restarting.

- Absolute value as a function of the fuel temperature

- Duration as a function of the fuel temperature

- Volume flow in stop phase 30 l/h

3. Volume flow offset depending on the battery voltage

Software extensions EC-EKP

[redacted] requirement:

- At low voltages, e.g. brought about by recuperation, high rotational speeds may not longer be able to be regulated by the fuel pump unit.

Agreed solution:

- An offset must be defined for the volume flow requirement depending on the injection volume and the rotational speed. This offset must be weighted with a factor which is calculated from the fuel temperature and injection volume.

- This offset replaces the previous base value.

4. Negative recuperation recommendation (DC-capable)

Software extensions EC-EKP

Non-responsive content removed requirement:

- At low voltages, high rotation speeds may no longer be able to be regulated by the fuel pump unit. One problem is that a higher fuel volume flow needs to be pumped at a high engine load, while at the same time the voltage through the recuperation is reduced.

Agreed solution:

- The motor control unit already issues a recommendation to lower the voltage above the applicable engine output. This negative recuperation recommendation must be extended such that the voltage is likewise not reduced above a configurable sampling ratio.

- A filter or a debouncing is to be provided in order to prevent a negative recuperation recommendation from being issued with a short-term increase of the sample ratio (positive load step).

Note:

- A negative recuperation recommendations must be agreed with the project.

- Debouncing via dead time

5. Negative recuperation recommendation (DC-capable)

Software extensions EC-EKP

[redacted] requirement:

- At high fuel temperatures, it may be necessary to control the fuel pump before starting the engine.

Agreed solution:

- In vehicles with automatic start, the start control is effected by the engine control unit. A delay is already implemented for the start ignition after actuation of the ZAS or ZAT. The existing interface is to be used to delay the start even when control of the fuel pump is required.

- The delay time must be dependent on the fuel temperature.

- The delay of the engine start should only take with the actuation of the ZAS or ZAT when there is a start release (clutch or brake pedal pressed and gear lever on automatic gearbox in position P or N).

- As the pre-glow time tends to be longer than the start delay time for the fuel pump, the timing should be set up so that the start delay also expires for the fuel pump when the pre-glow time ends.

6. Negative recuperation recommendation (DC-capable)

[redacted] requirement:

- The fuel continues to heat up in the over-run phase of the engine. The high-pressure pump is hot in the start and is not cooled down sufficiently by the hot fuel.

Software extensions EC-EKP

Agreed solution:

- To provide sufficient cooling and lubrication to the HPP in the hot start too, the electric fuel pump must also be initialized as of T. 15 ON and/or a door contact. The status must be kept active for an applicable run time depending on the fuel temperature and a volume flow must be issued in accordance with the fuel temperature. The functionality must be able to be deactivated/activated via a switch The functionality must be able to be deactivated/activated when the tank is empty, in the event of faults in the fuel system, and for the production above a configurable kilometer threshold.

- In order to cool down the HPP again, also in the over-run phase, and it must be possible to initialize the electric fuel pump in the over-run phase. In this case, the run time and the fuel volume flow must be configurable according to the temperature. The initialization of the electric fuel pump in the over-run phase must be deactivated depending on the cooling air control (PWM). This functionality must be able to be deactivated/activated via a switch. The functionality must be able to be deactivated/activated when the tank is empty, in the event of faults in the fuel system, and for the production above a configurable kilometer threshold.
→ Over-run for 2 s

7. Negative recuperation recommendation (DC-capable)

[redacted] requirement

Software extensions EC-EKP

- When turning off the engine (terminal 15 OFF), the engine still has an empty running speed at least and it takes up to 1.7 seconds until the engine is actually stationary. In this state, however, the fuel pump was already switched off because the pump goes into the control logic of the terminal 15 status.

- The result is a fall in the fuel pressure in front of the high-pressure pump when the engine/high-pressure pump is turning by itself.

Agreed solution:

- In the event that terminal 15 drops out, the pump is still operated further for an applicable time however not beyond the time when the engine comes to a standstill.

Diesel Systems

BOSCH

From	Processor	Phone	Fax
[redacted]			

[redacted]
6/10/2009
No. 986-166/01

Log

Recipients e-mail Distribution List
For Info e-mail Distribution List
Host [redacted]
Participants

Head [redacted]
Log
Organiz.
Date/Location **06/10/09, 2:00-5:00 PM,**
NSU, B12 middle conference room
Topic **CP4 technical discussion**

1) CR overview (attachment 1)

-The only ongoing CR is the cavitation CR.

[redacted]

[redacted]
7/1/2009

3) Optimization of C layer (attachment 4)

- AUDI asks how droplets in the C3 coating can be reduced
- Friction coefficient examinations, feedback of substance analysis values
- Participation of QA and workshop representatives required.

[redacted]
7/1/2009

4) Powertrain damage

Not covered because [redacted] were absent.

5) VFA delivery

[redacted]

[redacted]

[redacted]

Further development of C3 layer system for C4 roller support: C3.1

Compare properties C2.1 and C3 in CP4 roller support

			Wear resistance			Friction coefficient
Layer	**Surface roughness**	**Damaging effect of layer particles**	**Vibration stress**	**Impact stress**	**Cavitation**	
C2.1	Substrate + individual layer faults	0	0	0	0	+
C3	Substrate + process-linked droplets	-	+	+	+	0

EA11003EN-01546[1]

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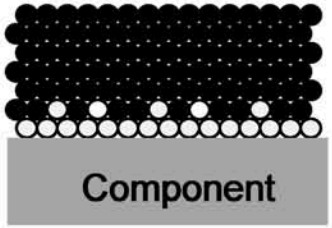
Further development of C3 layer system for C4 roller support: C3.1

Comparison of C2.1 and C3 series version with C3.1

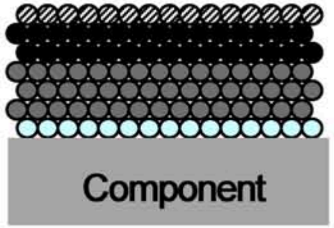
Layer structure

C2.1 layer



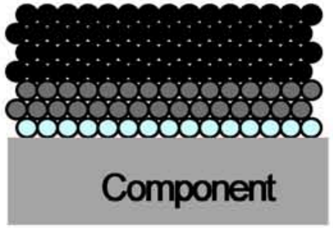
- C1 protective layer with constant hardness
- Transition layer
- Adhesive layer 1

C3 layer



- C1 protective layer with hardness gradient
- C2 layer
- Adhesive layer 2

C3.1 layer



- C1 layer with constant hardness
- C2 layer
- Adhesive layer 2

● Carbon 1 layer (=C1)

● Carbon 2 layer (=C2)

○ Adhesive layer 1

○ Adhesive layer 2

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Expected properties of C3.1 layer

- Increased wear protection compared to C2.1 thanks to thin “C2” layer for
  - impact stress
  - Vibration/sliding stress
  - Cavitation attack
- Friction properties in “critical” media favorable like C2.1
- Lower number of droplets compared to C3 through thinner C2 layer
  - Lower risk of droplet outbreaks during operation
- Layer particles less harmful than C3 particles
- Robust adhesiveness like C3
- ”C2.1 layer with C3 base as safety reserve”

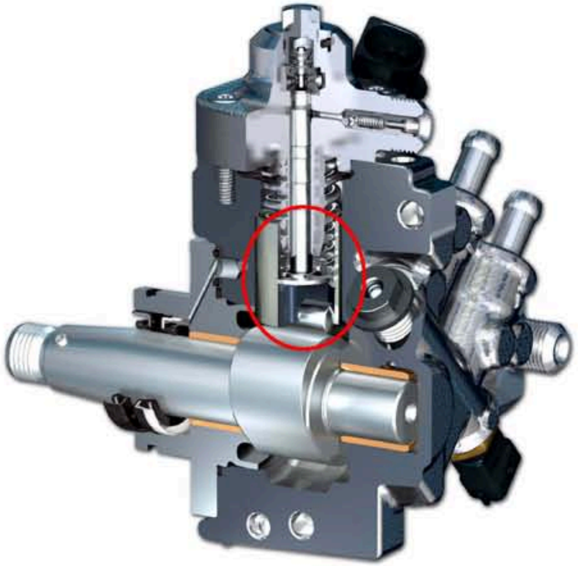
ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

1. Change no.

DS-002 036 219
[AUDI..611,..619,..620,..624 Eu5]
DS-002 036 221
[AUDI ..613 BIN5]

2. Product:

Bosch No.	Customer no.
0 445 010 611	[Audi]
0 445 010 613	[Audi]
0 445 010 619	[Audi]
0 445 010 620	[Audi]
0 445 010 624	[Audi]



ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

3. Description

Introduction of optimized roller tappet

Polished tappet body

Cylindrical press-fit assembly

increased pressing dimension

3.1 Base

Improvement and stabilization of the press-fit assembly tappet body / tappet body through:

Omission of tolerance restriction

Omission of the settling behavior of manganese phosphate coating

Increase in pressing force

> Reduction of side roller start-up

ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

4. Details

As-is

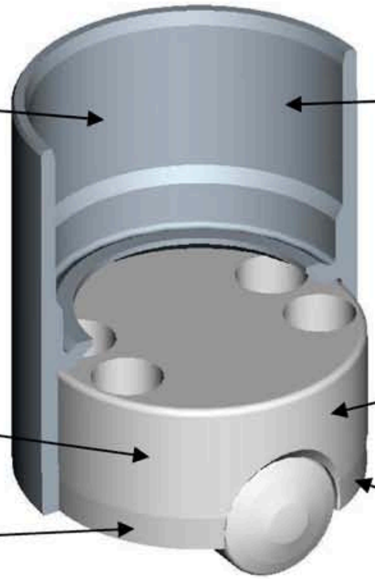
Tappet body

Manganese phos-phate coated (all areas)

Roller support

Semicircular diameter

Pressing length 9.3 mm



new

Tappet body

- uncoated

Roller support

- Cylindrical diameter
- 7µm increased pressing dimension
- Pressing length 8mm

ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

4.1 Omission of manganese phosphate coating on the tappet body

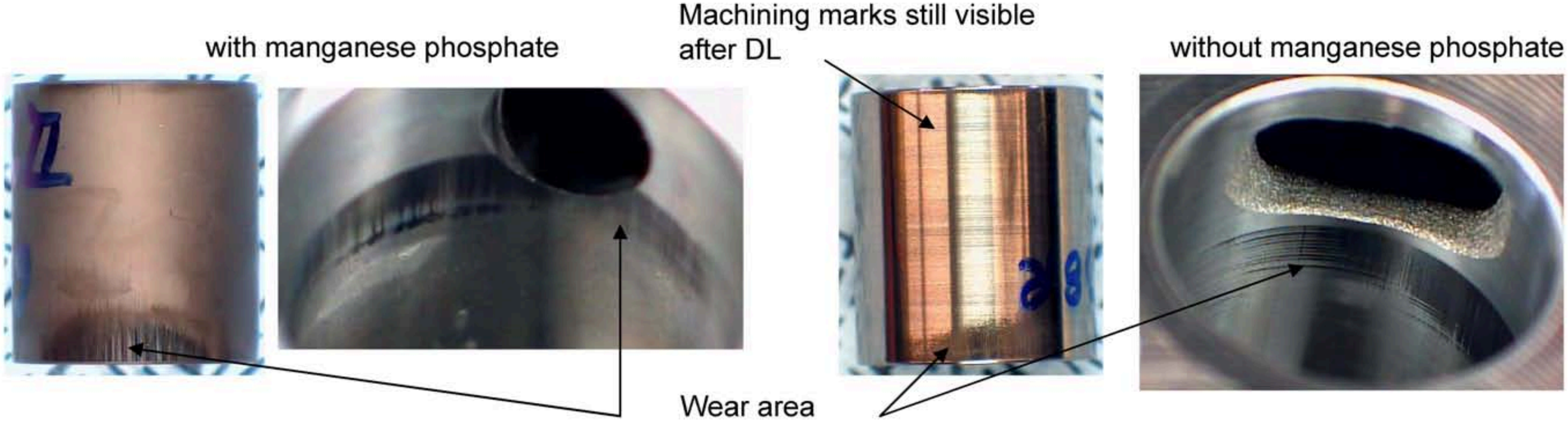
advatages:

- No tolerance restriction in the press-fit assembly through varying coating thicknesses

Omission of the settling behavior of manganese phosphate over its service life, i.e. the extrusion force of the roller support after continuous running time is about 30 - 40% higher without coating than with coating

Lower coefficient of friction between the tappet body and the housing, thus improved inlet behavior, reduced wear and lower risk of particles

Comparison of tappet body & housing after 2,000 h ensurance run: no difference in the wear pattern



Diesel systems

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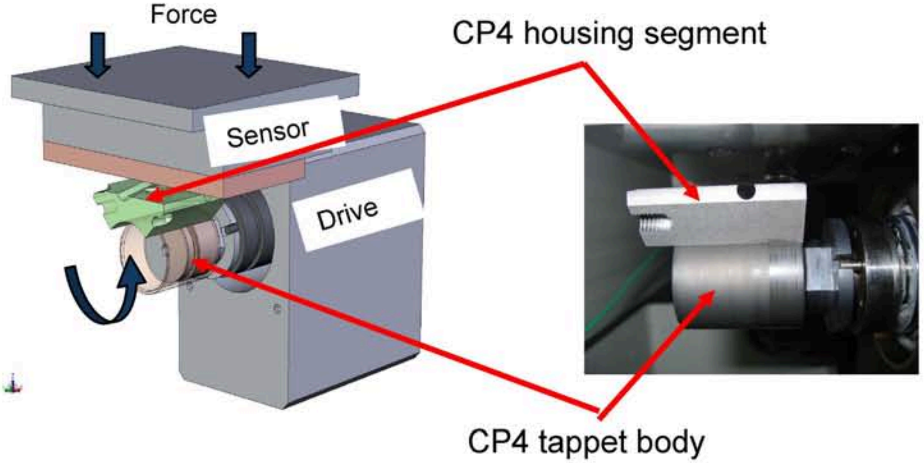
ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

Tribology test for determining coefficient of friction



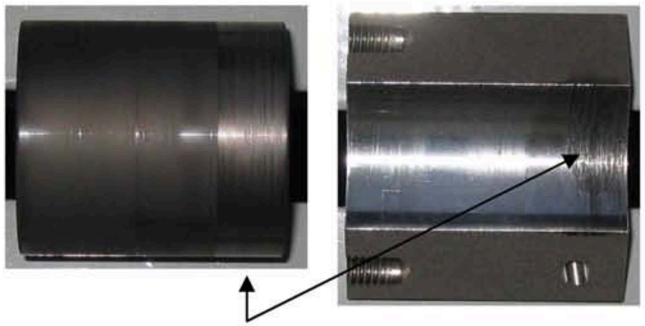
Evaluation:

Lower coefficient of friction with lower scattering at the same time

Better wear behavior

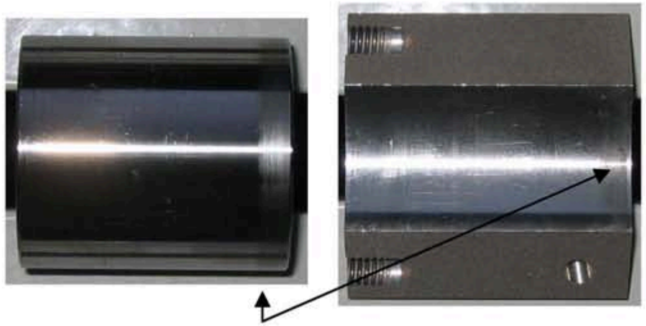
= Efficiency & robustness increase

with manganese phosphate



Considerable abrasion

without manganese phosphate



Slight incipient abrasion

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ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

5. Validation of Bosch

5.0 Function		
Tribology tests	settled	☺
FEM calculations	settled	☺
Conducting trial mounting of roller tappet	settled	☺
Functional tests	settled	☺
5.1. Quality Assurance		
FMEA	settled	☺
DRBFM	settled	☺
5.2 Durability / continuous runnings		
Pump continuous runnings (a total of ≈ 32,000 h)	completed	☺

ÄAS DS-002036219, -36221 CP4 roller tappet introduction of optimized press-fit assembly

6. Validation of customer

RB proposal not required

With optimized press-fit assembly at sample pumps delivered to AUDI
8 x CP4 20/2 for W19 Bin5/EU6 …755AL(February 2009, 0 445 B20 169_20)
239 x CP4 18/2 for W36 D4 …755AN (0 445 B20 246_x)
207 x CP4 20/2 for W36 Q7 …755Ak (0 445 B20 249_x)
10 x CP4 20/2 for W37 …755AP (0 445 B20 252_01 & _02)
19 x CP4 22/2 for W37 …755AQ (0 445 B20 252_03)

7. Launch date

12.01.2009

8. Risk

no risk

9. Alternatives

none

10. Remark

Optimized press-fit assembly is in series production at other customers

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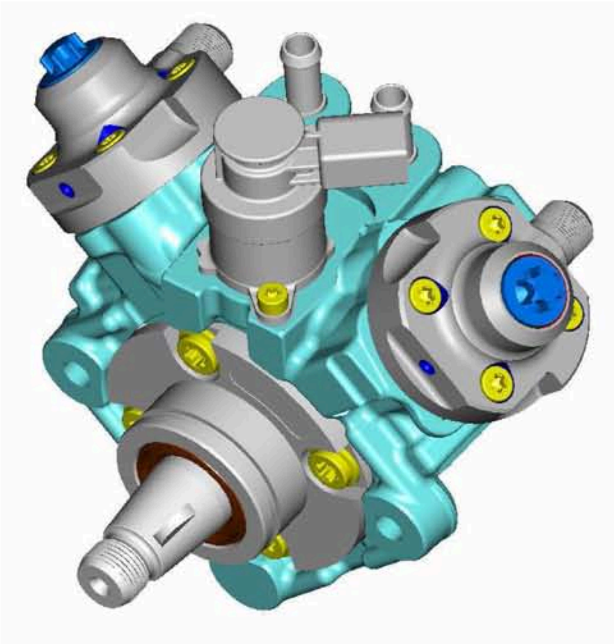
Agenda, 28/10/2005, VW Presentation CP4

- Platform
- Design
- Rating
- Trial
- Drive
- Pump construction for VW, schedule

BOSCH

CR high-pressure fuel pump CP4

Annex 1.2

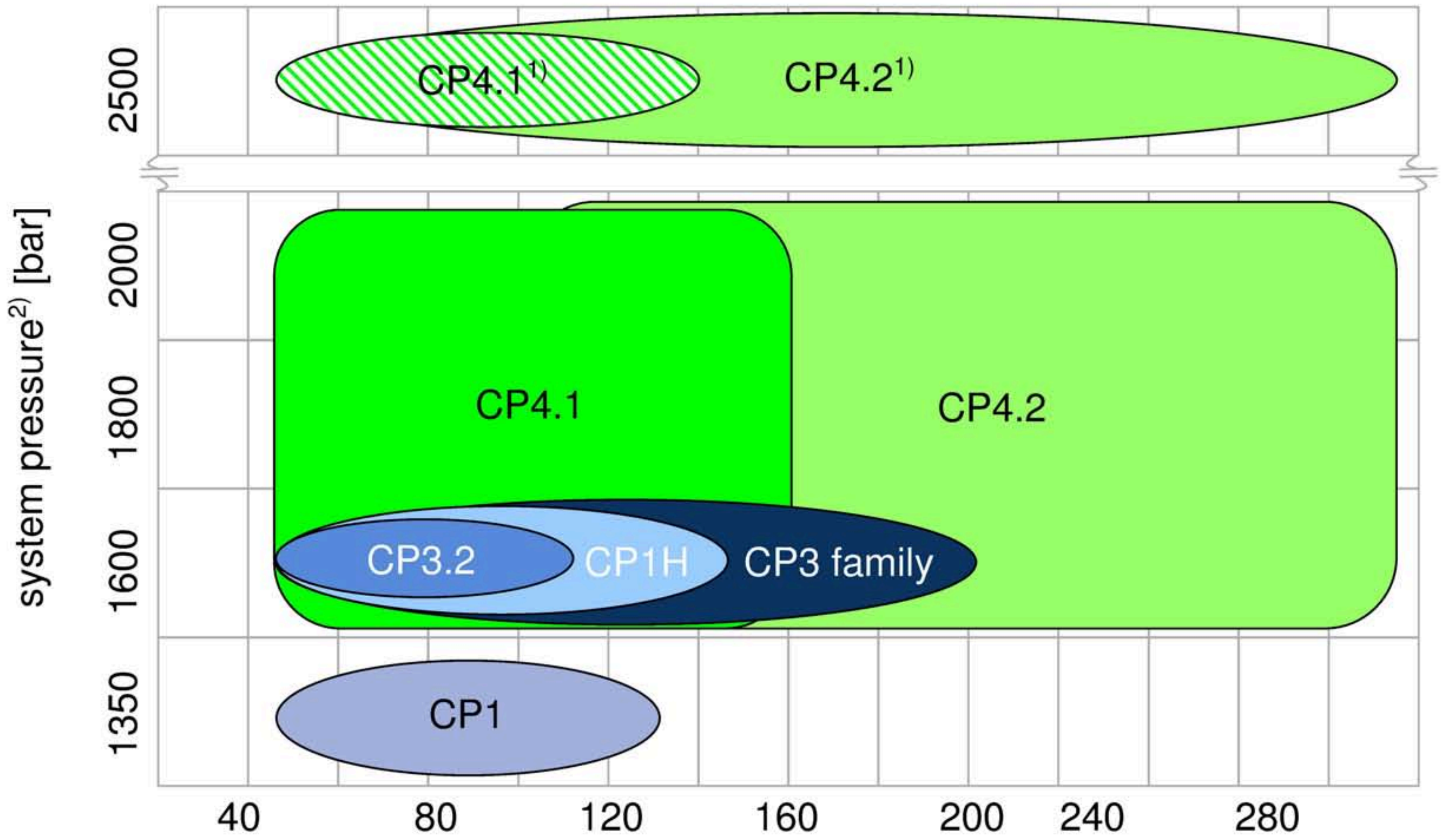


Characteristics

- Internally supported radial piston pump
- 1 or 2-plunger pump (V90°)
- Multiple cam and roller tappet
- Aluminum housing (no HP duct)
- Steel cylinder heads with integr. HP valve
- 1 or 2 HP lines to rail (1 piece/2 piece)
- Suction-side metering via UM
- EFP and integrated, mechanical presupply pump (CP) possible
- Clockwise/anticlockwise rotation
- Synchronous feeding with 4, 6, 8-cyl.
- Oriented engine-mounted installation

CP roadmap

Annex 1.3

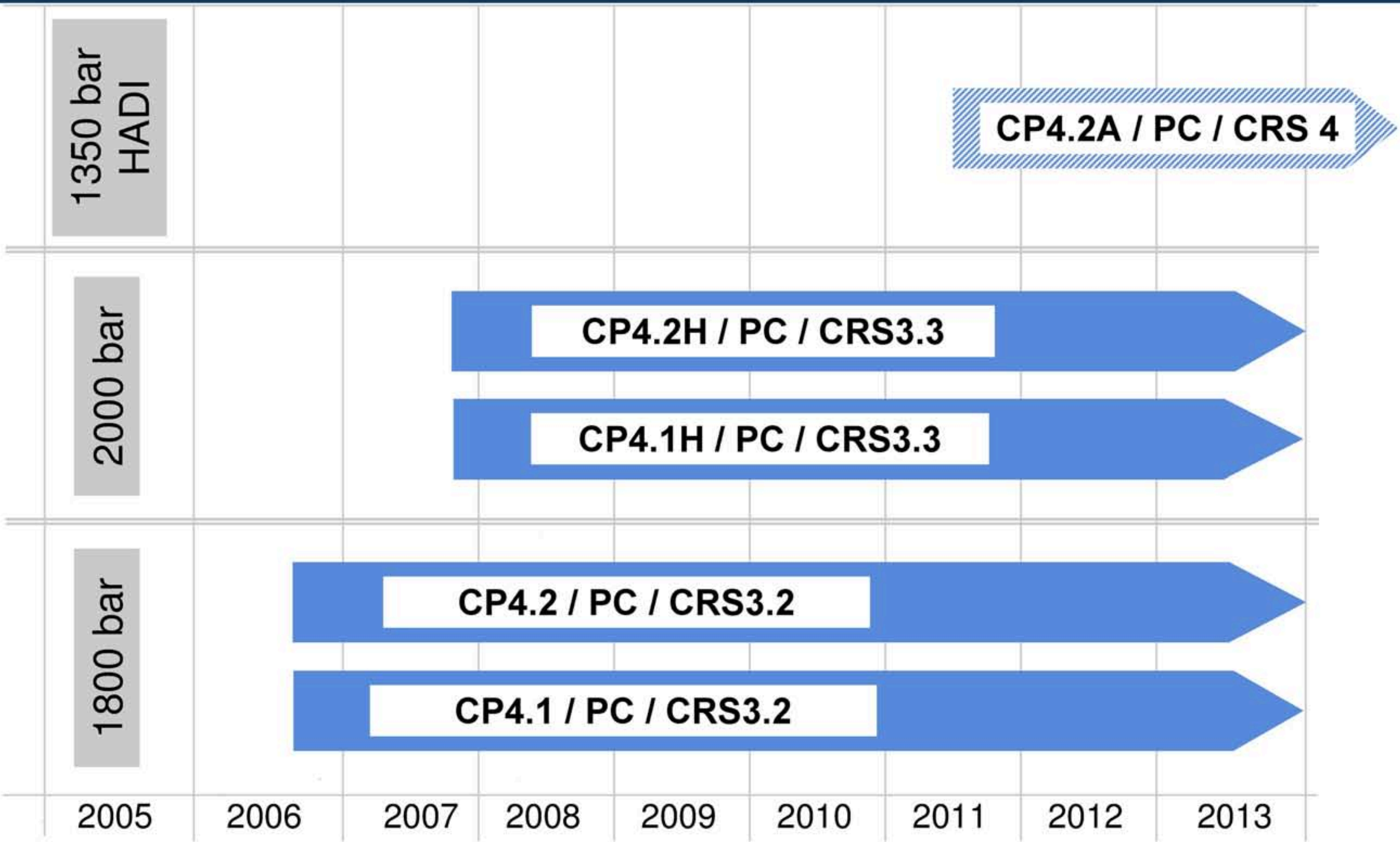


1) - pressure-intensified systems, pump and rail pressure 1350 bar
- project currently postponed

2) pressure at nozzle during pressure intensification

CP4 roadmap

Annex 1.4



: project decided

: project freeze 10.2005, postponed SOP planning 2011

CP4 Platform

Annex 1.5

Applications:	• PC -, LD-, MD - engines with 3, 4, 5, 6 and 8 cylinder, potential up to 12 cylinder
Platform:	• 2 - plunger pump incl. housing • flange-Ø = 50 mm, pitch circle-Ø = 105 mm • 1 - plunger pump incl. housing
Application parameter:	• pump speedi = 1/2, 3/4, 1/1, 3/2, (2/1) • plunger lift • plunger- Ø (only pressure amplified FIE)
Options:	• mechanical feed pump • US-fuel

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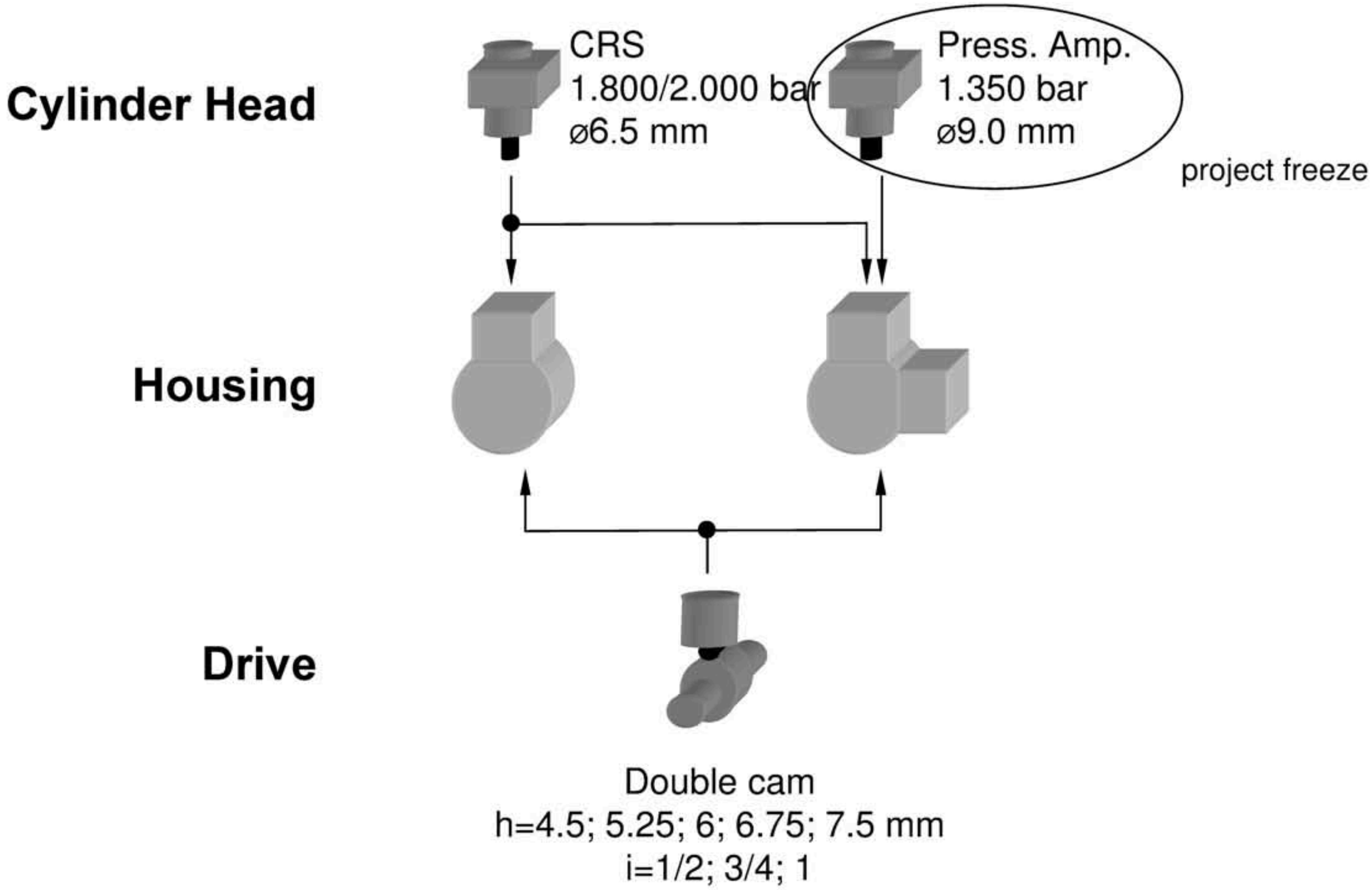
CP4 Modular Concept



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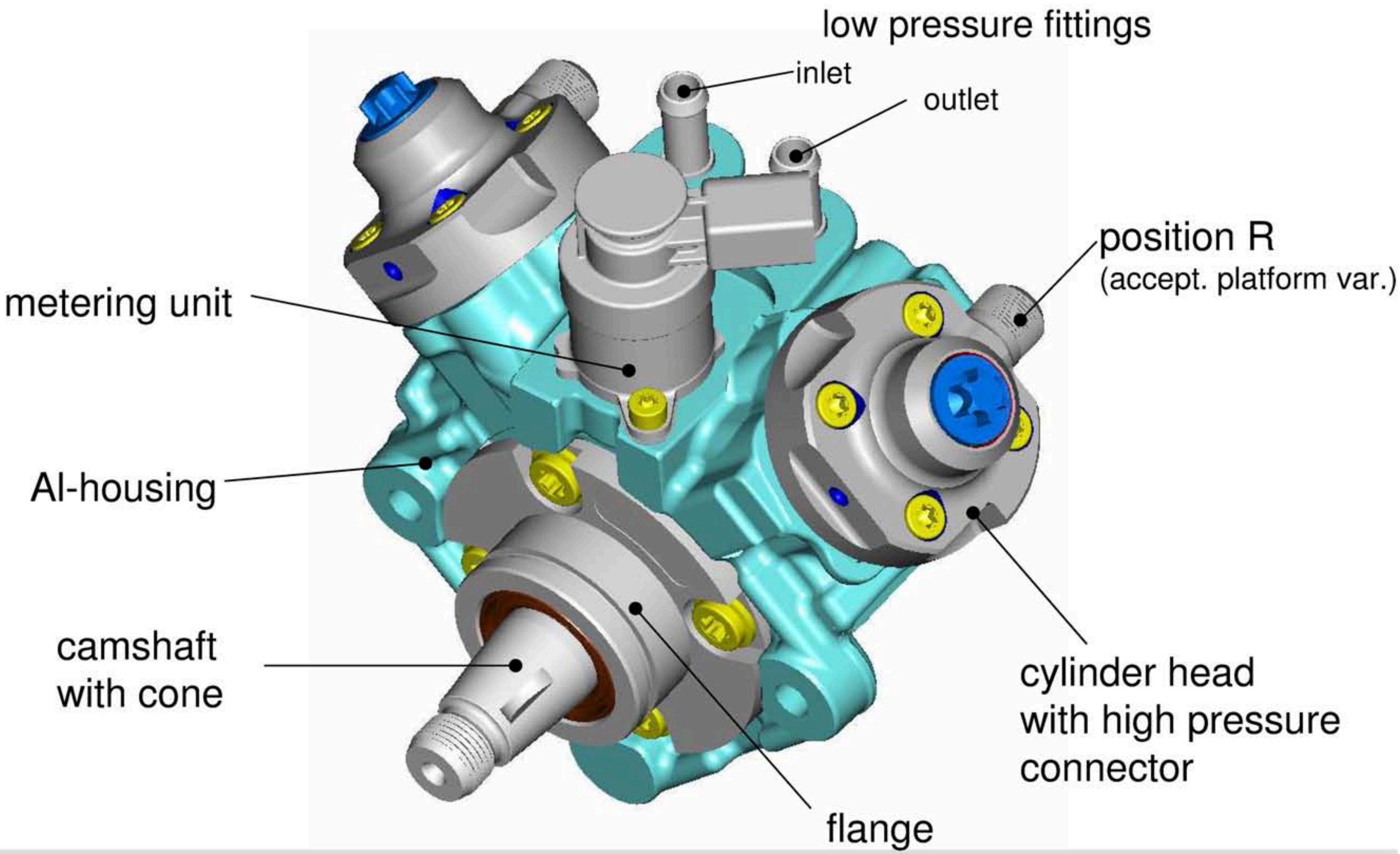
CP4 Overview - Technical Information CP4.2 (1)

Annex 1.7



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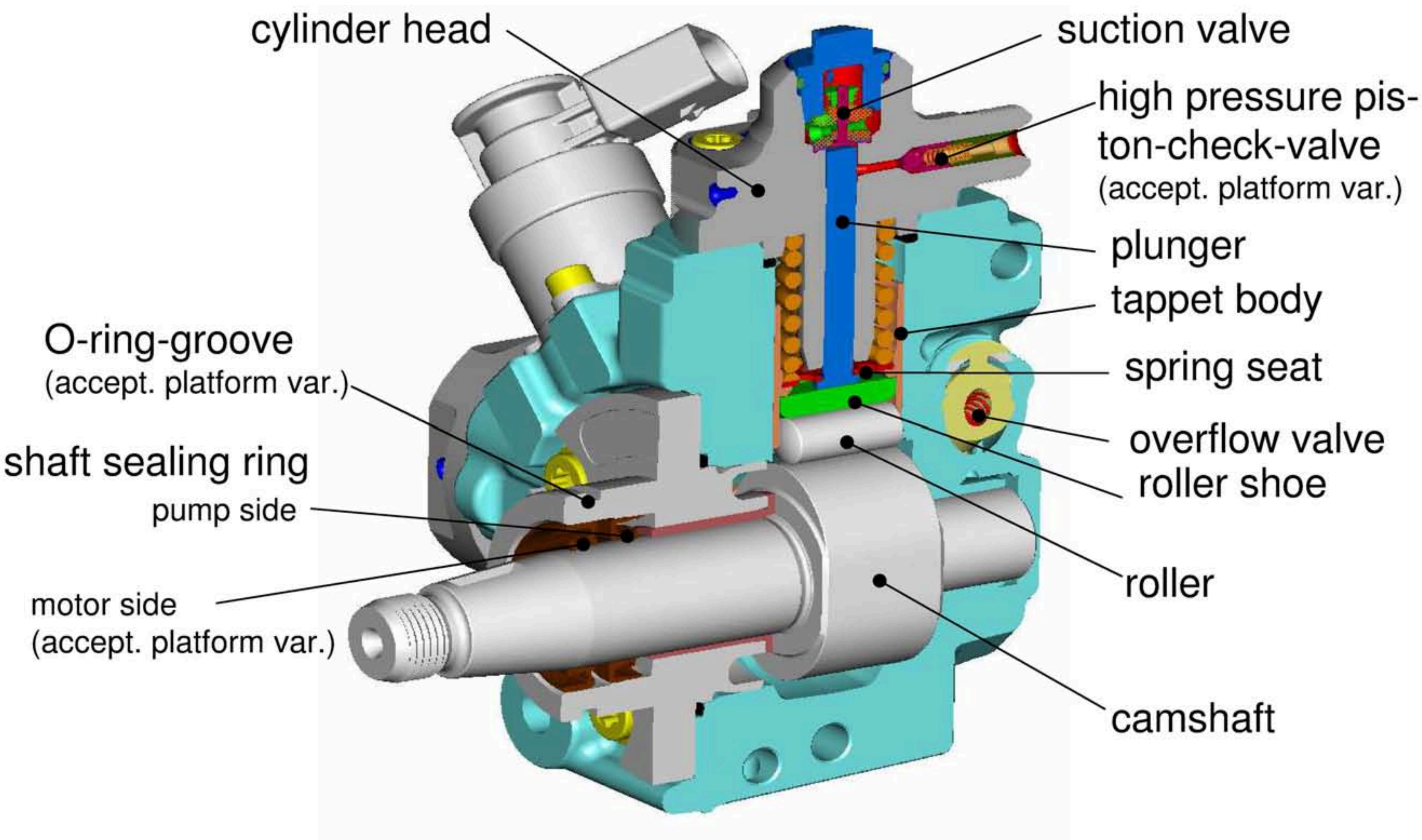
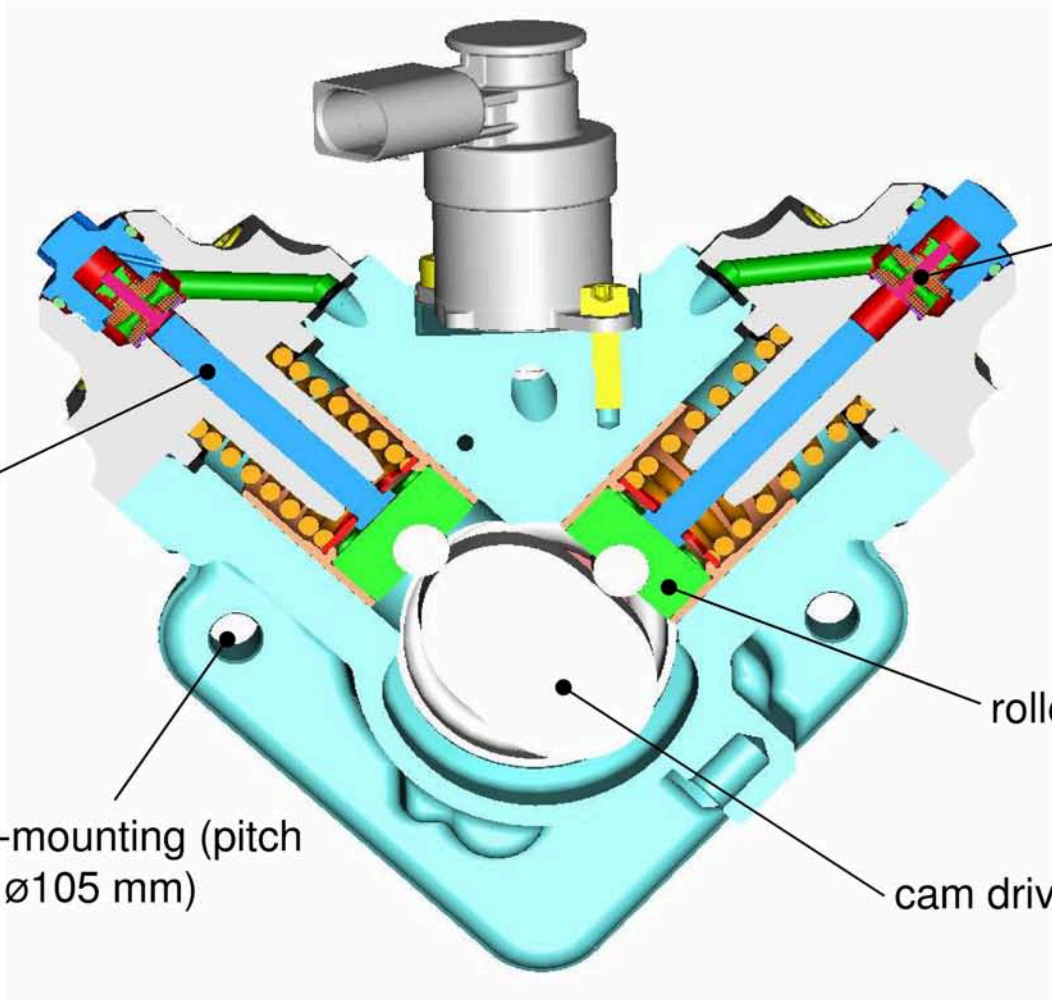
CP4 Overview - Technical Information CP4.2 (2)

Annex 1.8



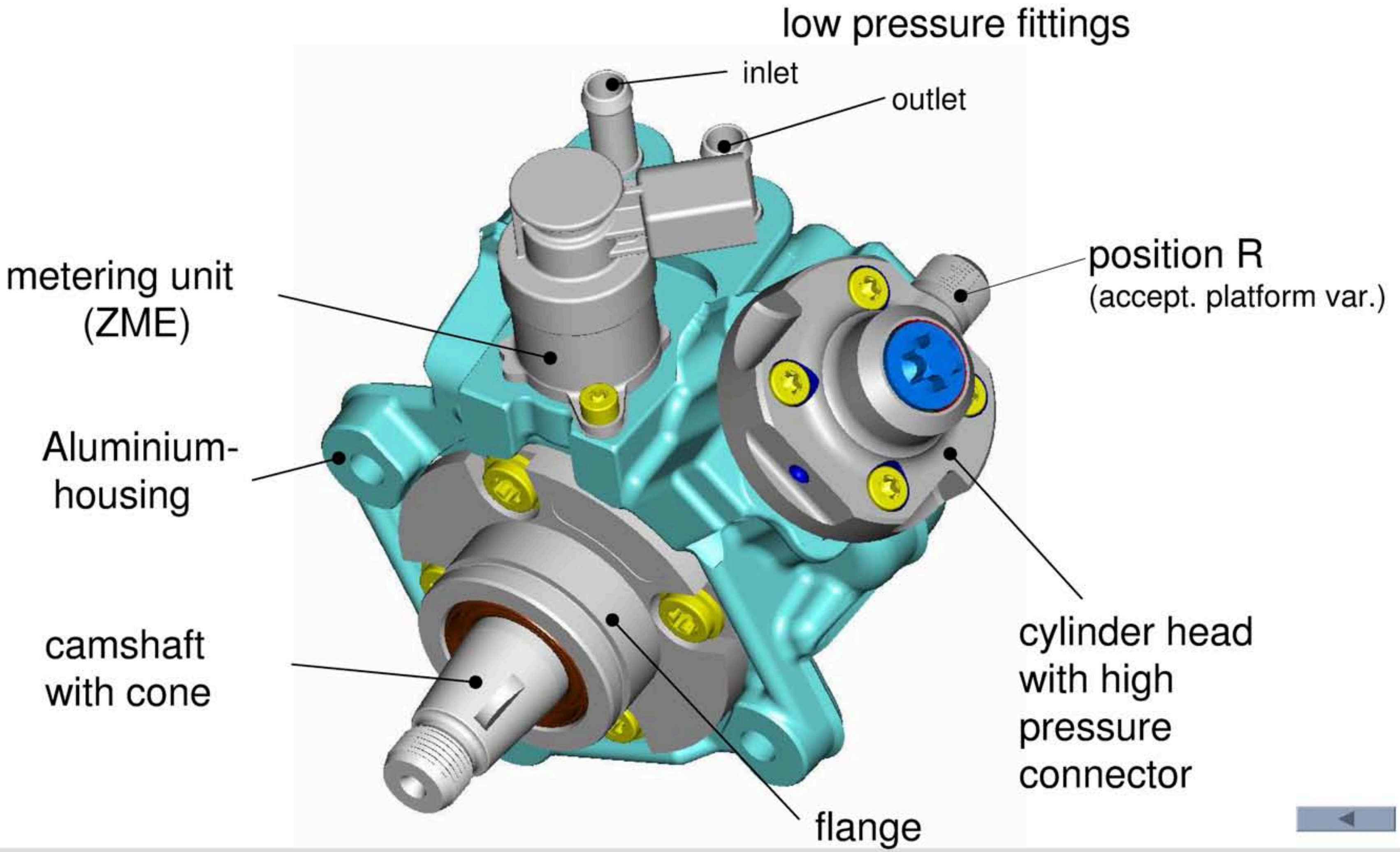
CP4 Overview - Technical Information CP4.2 (3)

Annex 1.9



CP4 Overview - Technical Information CP4.1

Annex 1.10



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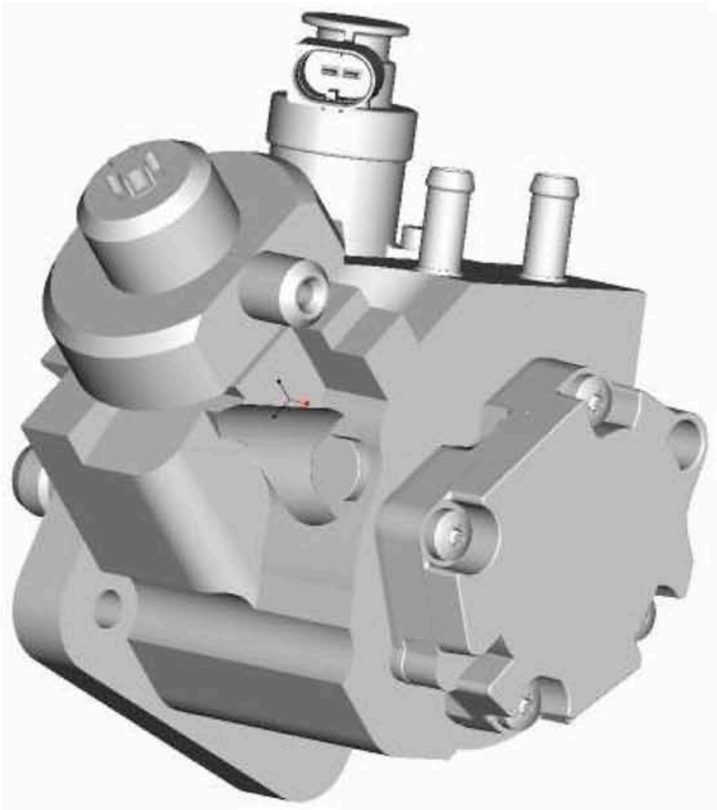
CP4.1 with mech. FP (CP)

Annex 1.11



Comparison common rail high-pressure fuel pumps

Annex 1.12

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				CP4.1
Ratio i		[-]	[redacted]	1
Pitch		[mm]		6.0
Piston diameter		[mm]		6.5
Feed rate		[mm³/rev]		398
Engine speed n_{max}	with mech. FP	[rpm]		4,500 (i=1)
	without mech. FP	[rpm]		4,800 (i=1)
Efficiency @ 1000/min, 80 °C		[-]		> 80 %
Customer SOP	with mech. FP	-		07/2008
	without mech. FP	-		09/2006
Pressure		[bar]		1,600 1,800 2,000
Pressure curve		-		
Weight without mech. FP		[kg]		3.0
Picture		-		
Animation		-		

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ENTIRE PAGE CONFIDENTIAL

Evaluation matrix common rail high-pressure fuel pumps for VW R4 2.0 1 "low"

Annex 1.15

		Non-responsive content removed [redacted]	CP4.1
System pressure	1600 bar		X
	1800 bar		X
Ratio			1
max. power 130 kW			+
Emissions package	EU5		+
	US07		+
Efficiency			+
Installation space/package			0
integr. FP			From 7/2008
Maturity			0 (43,000 h)
Availability (adjusted pumps)	Construction stages		Yes
	Series		Yes

Deadlines

* previous series experience: 6 years

CP4 Overview - Performance

Annex 1.16

Technical Data

Drive ratio	0,5 \ 0,75 \ 1,0
Max. delivery rates	≤ 90/135/180 l/h (CP4.2)
Max. rated speed	4.500 1/min (w. mech. FP)
High idle	5.000 1/min
Cool- / lubrication quantity	typical 50 l/h at rated speed
Pump inlet temperature	≤ 70°C, short time 80° (100h), 90°C (100h)
Inlet pressure	4 ... 6* bar_{rel} with EKP
	0.5 ...1.0 bar_{abs} with mech. feed pump
Back flow pressure	0.6 ...1.8 bar_{abs}

*preliminary

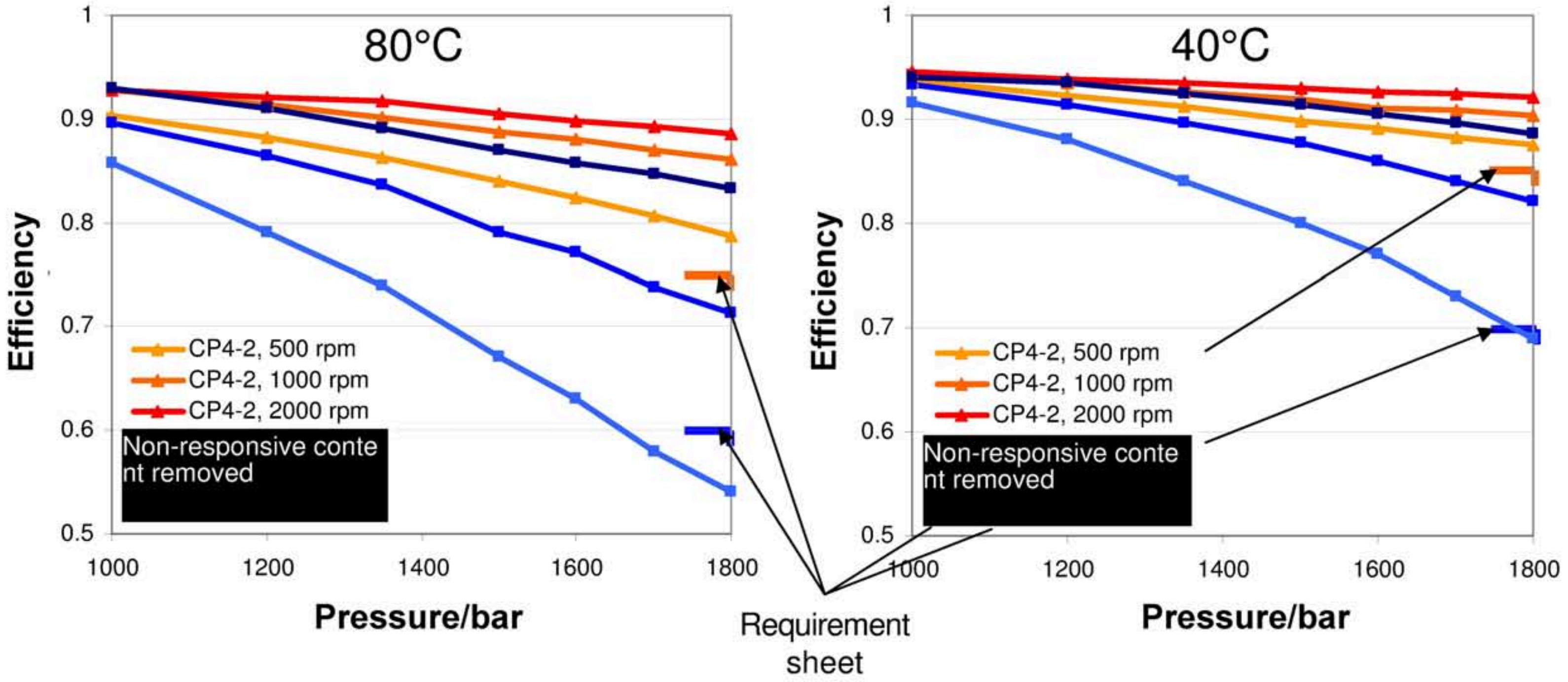
ENTIRE PAGE CONFIDENTIAL

CP4 Efficency

Annex 1.17

Comparison CP4-2/995 vs. [redacted]

Volumetric efficiency @ different inlet temperatures



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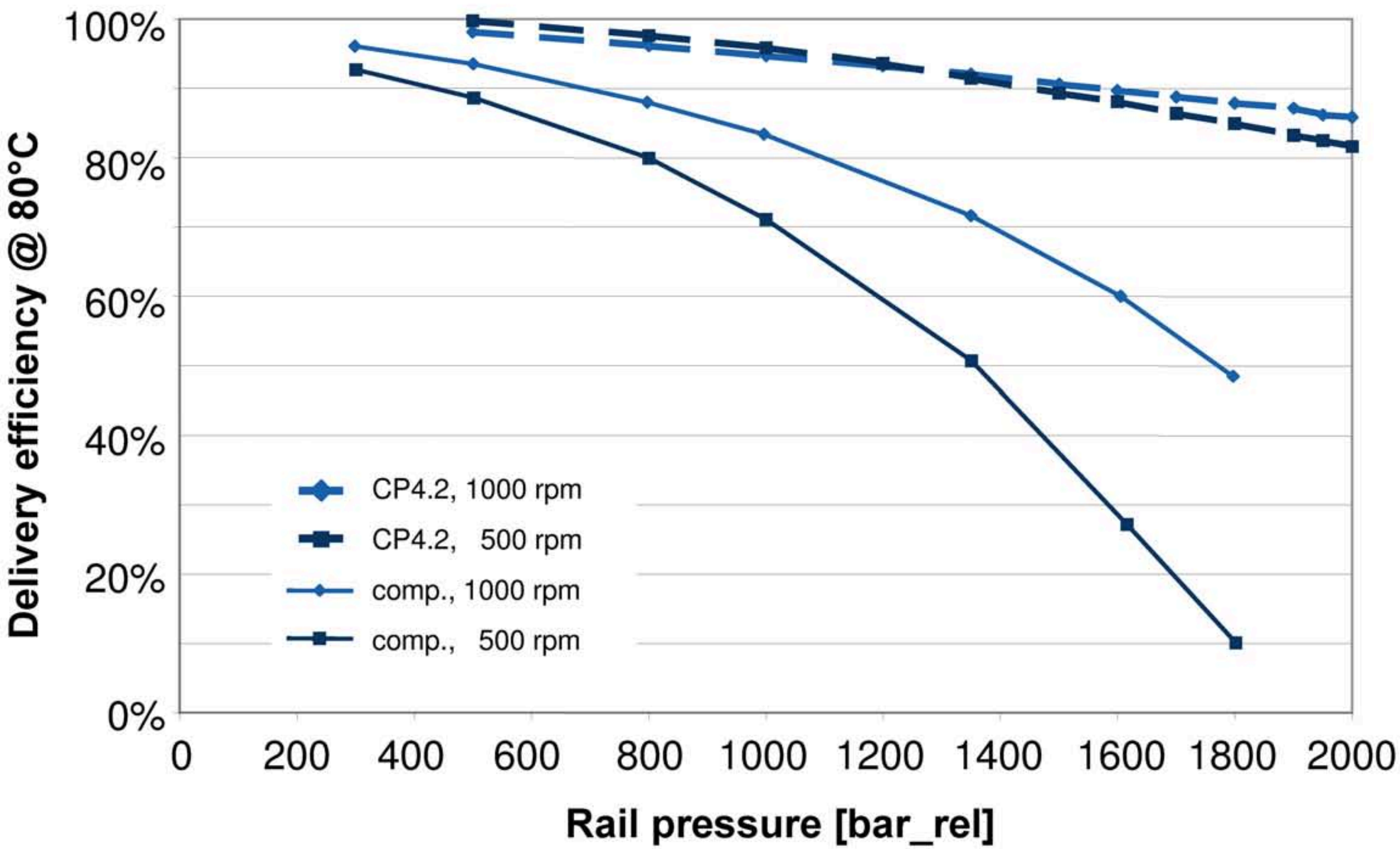
CP4 efficiency

Annex 1.18

Efficiency comparison: CP4.2 vs. competitor



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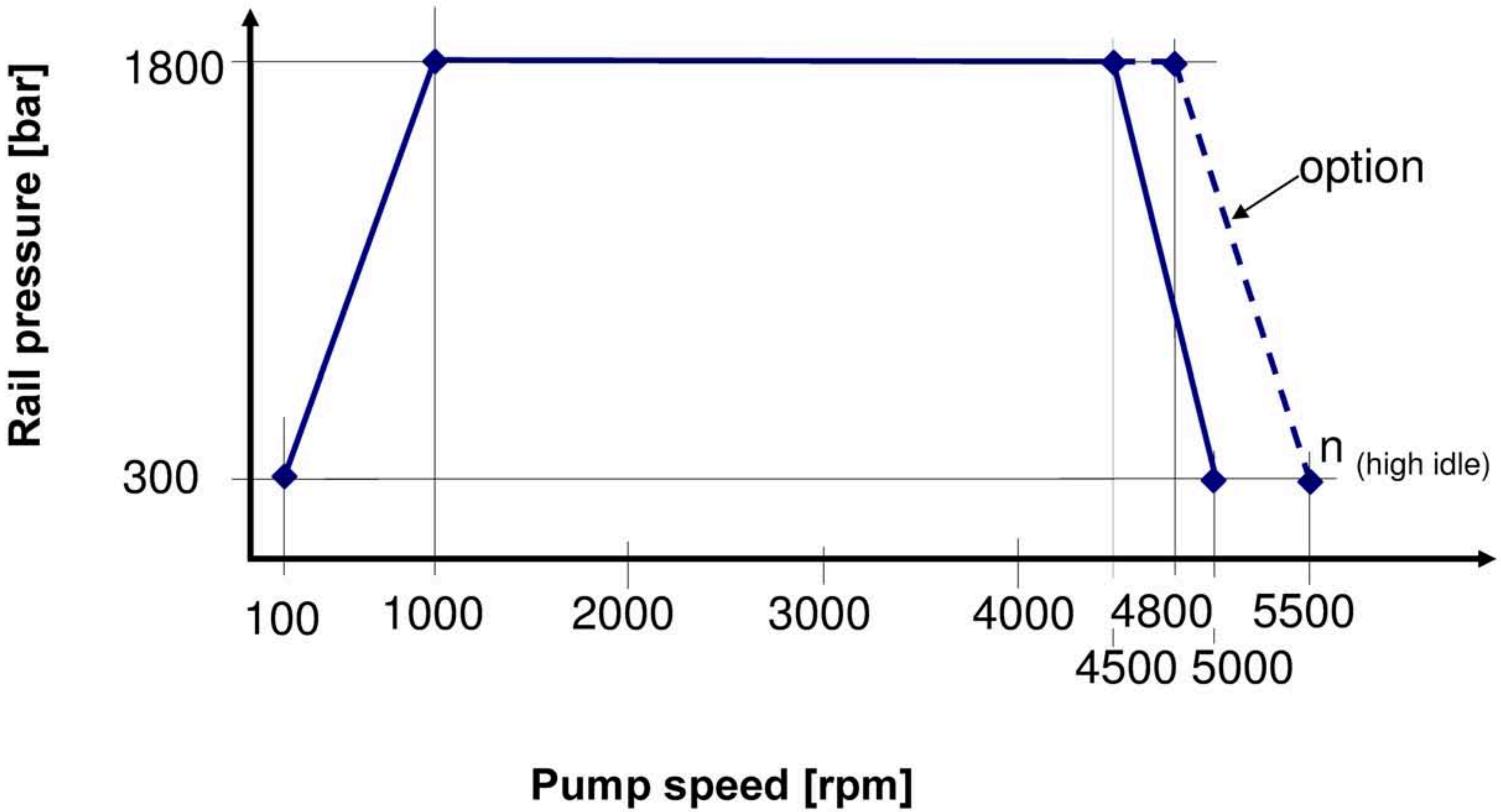
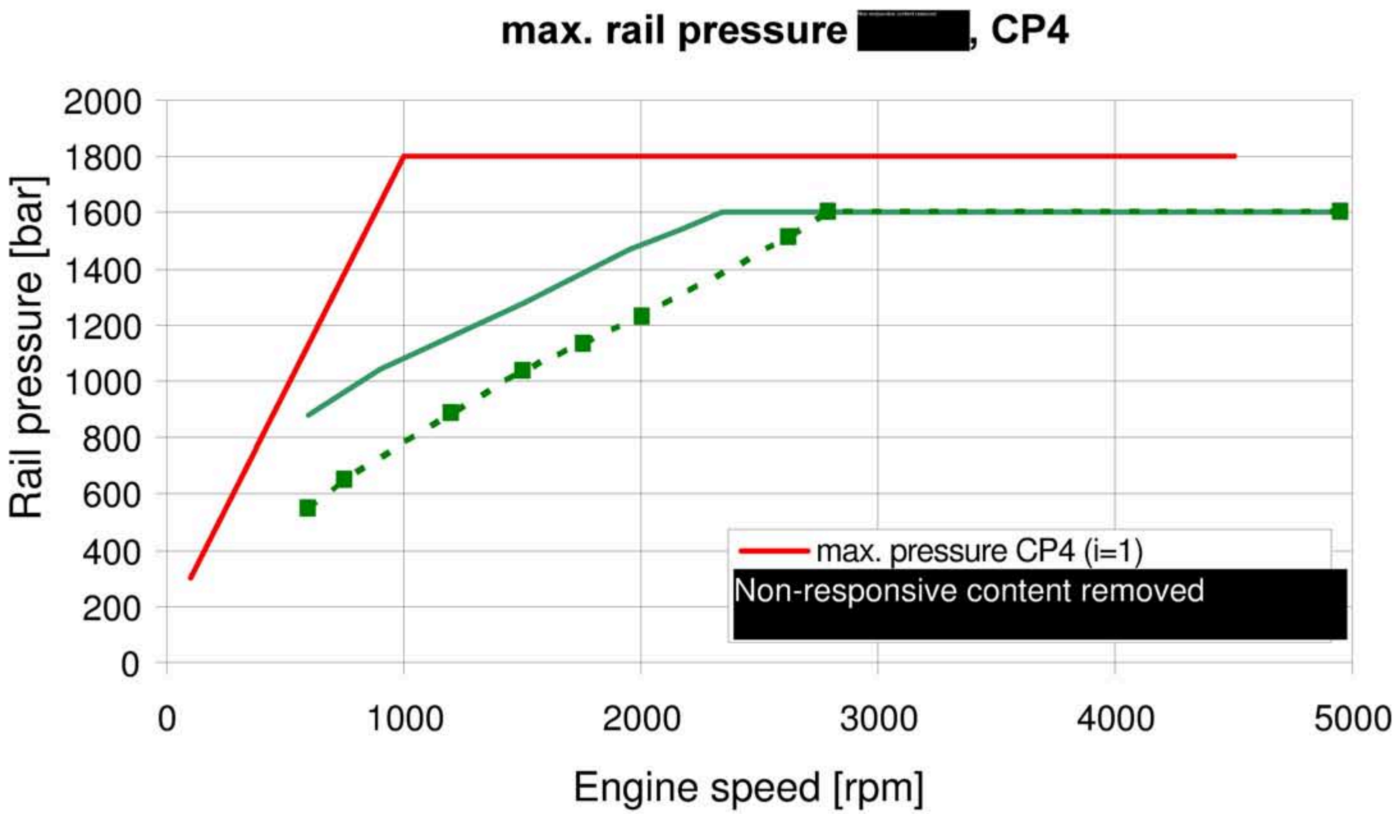
CP4 - Rail pressure diagram 2 cam lobes

Annex 1.19



CP4 - rail pressure diagram (double cams)

Annex 1.20



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CP4 quality and customer benefits

Annex 1.22

CP4

General:

- New generation of CR HP pumps with high pump frequency
- Significantly improved hydraulic efficiency
- lower power losses
- Additional quantity and pressure potential

Drive

- Roller tappet (roll contact) instead of polygon (sliding contact)
- Avoidance of mixed friction allows greater Hertzian stress
- Cam profile optimization allows improved feed rate

High-pressure/low-pressure seal points:

- Reduction of high-pressure seal points:

  Non-responsive content removed CP4.1: 2 pieces CP4.2: 4 pieces

- Reduction of low-pressure seal points:

  Non-responsive content removed CP4: 1 locking ball

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CP4 trial

Annex 1.23

2 standards of testing

Standard tests
(constant load- and program-endurance tests)

Long-term testing with practice orientated standard operating conditions in specification

Target: finishing tests without failure
B10-design validation

HAL tests
(= **H**ighly **A**ccelerated **L**ifetime **T**ests)

operating conditions increased out of specification

Target: forcing failures

BOSCH

CP4 trial

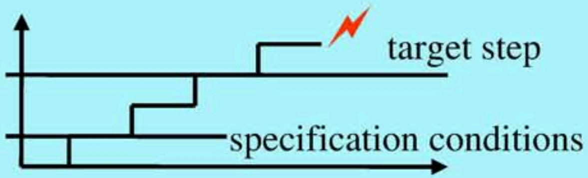
Annex 1.24

HAL test

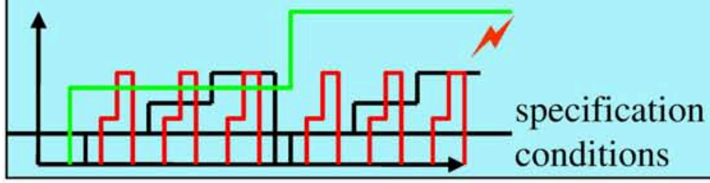
1. Determination of weak points
2. Comparison of counter measures
3. Design validation

Stepped tests

a) 1 parameter: p, n, T, ...



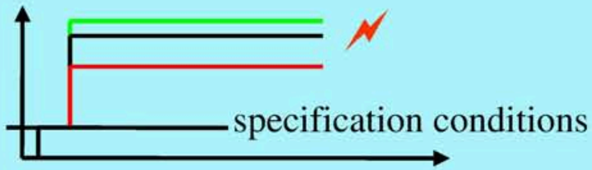
b) Several parameters: p, n, T, ...



1. Comparison of counter measures

"Crash tests"

a) Selected operation condition to force one special failure: p, n, T, ...



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Sample complaints CP4

Annex 1.25

Customer failures as at 14/10/05

Pump type	Cause of failure	Sample level	Quantity
CP4.1S	Oldham worn out	B1.1 B3	4 1
CP4.1S	Roller / cam wear, bearing melted	B1.1	1
CP4.1S	Chip in the intake valve seal seat (source: UM flange reworking)	B1.1	1
CP4.2	Oldham broken (dihedron and clutch piece) roller surface fatigue, surface roughness NOK	A1.1	1
CP4.2H	Overflow valve claw plate broken	A1.2	1

Quantity of customer pumps delivered: 350

Sample complaints CP4

Annex 1.26

Failures* as at 14/10/05

Pump type / Sample level	Customers CP4.1	Customers CP4.2	Remark
A1	- / -	2 / 10	CP4.1 no A1 sample delivered
B0/B1	6 / 74	0 / 64	Last sand casting versions
B2	- / -	0 / 15	CP4.1 no B2 sample delivered
B3	1 / 100	0 / 87	With customer since WK 20/05

* No. of failures / no. of delivered pumps
total: 350 pumps

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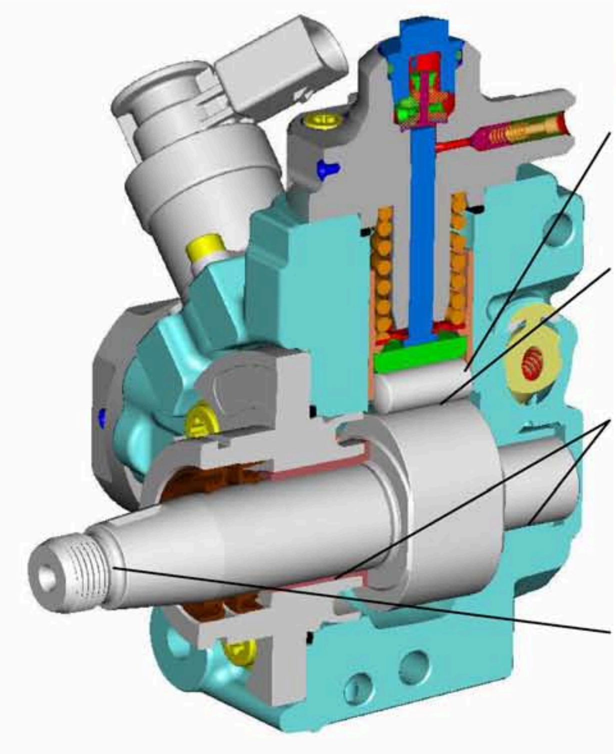
CP4 status durability test with RB

Annex 1.27



Optimization point	Solution approaches
Start-up on face of roller on tappet body	• Roller support: Minimization of incorrect positioning roller axis to cam axis • Further parameter optimizations * *
Durability of roller / cam drive	• Grinding parameter optimization on roller support and cam track * * • Improved C coating on roller support **
Durability of flange and housing bearing	• Modified LP circuit * • Improved bearing material (PEEK) * • Anhebung Grundspiel um 5µm bei beiden Lagern * • Diameter of housing bearing 22mm (previously 20mm) * • Stiffening of housing / camshaft *
Durability of Oldham coupling	• Application upper limit 1,800 bar

* Implemented from C0
** Feasibility in C1 sample

CP4 drive damage

Annex 1.28

CP4

- Main error in internal trials
  - Start-up on face of roller/tappet body
  - Wear roll/cam track
- Main causes
  - Incorrect positioning/angle between roller and cam axis
  - Start-up and locking of roller in tappet body
- Measures
  - Task force to investigate cause of damage and take remedial actions set up
  - Cause of damage understood
  - Immediate measures implemented in CO sample
  - Further measures under investigation, implementation in C1 sample as appropriate

BOSCH

CP4 status durability test with RB

Annex 1.29

Status durability text CP4

Program durability test, 2,000 h

- 1,800 bar (CP4.1/CP4.2) 22 test objects / 3 passed
- 2,000 bar (CP4.1/CP4.2) 5 test objects / 3 passed

Constant durability test (specification limits) 1,000 h

- 1,800 bar (CP4.1/CP4.2) 2 test objects / 2 passed
- 2,000 bar (CP4.1/CP4.2) 3 test objects / 1 passed

HALT * (n-, p-, T-, FL-)

- 1,800 bar (CP4.1/CP4.2) 16 test objects / 10 passed
- 2,000 bar testing in progress

* HALT = highly accelerated lifetime test

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CP4 status durability test with RB

Annex 1.30

Start / stop durability test

1 test object / 1 passed (CP4.2)

1,000 h, 300,000 cycles (50% with pressure maintenance function)

Total running time

• CP4.1 1,800 bar: 43,000 b	B sample
• CP4.2 1,800 bar: 25,000 h	B sample
• CP4.x 2,000 bar: 8,000 h	A sample

Positive highlights of HAL testing with A, B samples:

- HAL durability test successfully passed up to 2,750 bar
- HAL durability test successfully passed up to 6,000 rpm
- First positive HAL results with poor-lubricity fuel

HALT: Highly **A**ccelerated **L**ifetime **T**ests)

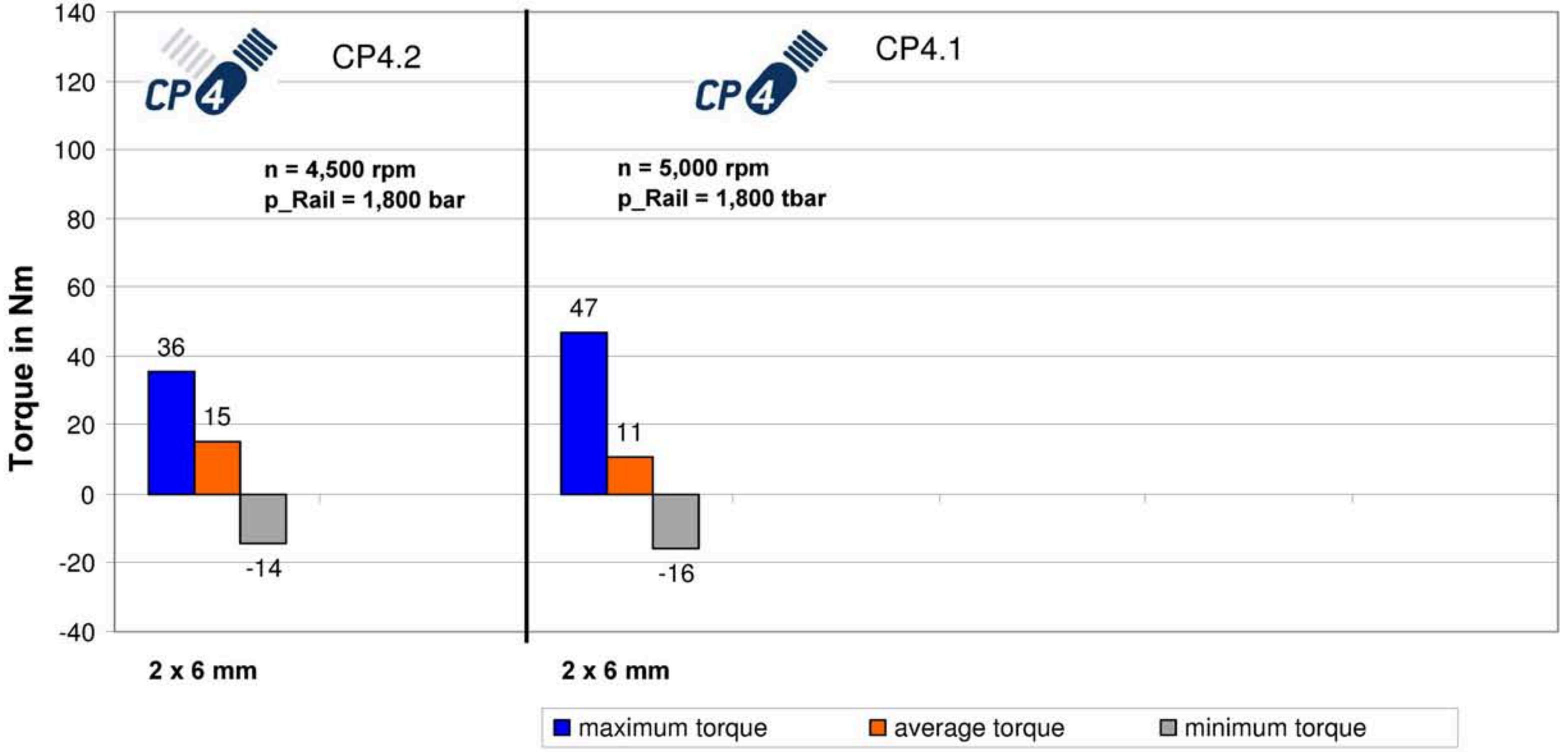
Objectives:

- high reliability in series production
- utilize CP4 future potential

CP4 drive torque

Annex 1.32

Measurements with EFP version, cone drive



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CP4 drive torque

Annex 1.33

Main factor influencing the maximum torque of the pump drive is the pump installation:

- ➔ **lowest values with cone direct drive (chain, toothed belt, gear)**
- ➔ **Increase up to factor 3 with Oldham or loose entrainment drives**

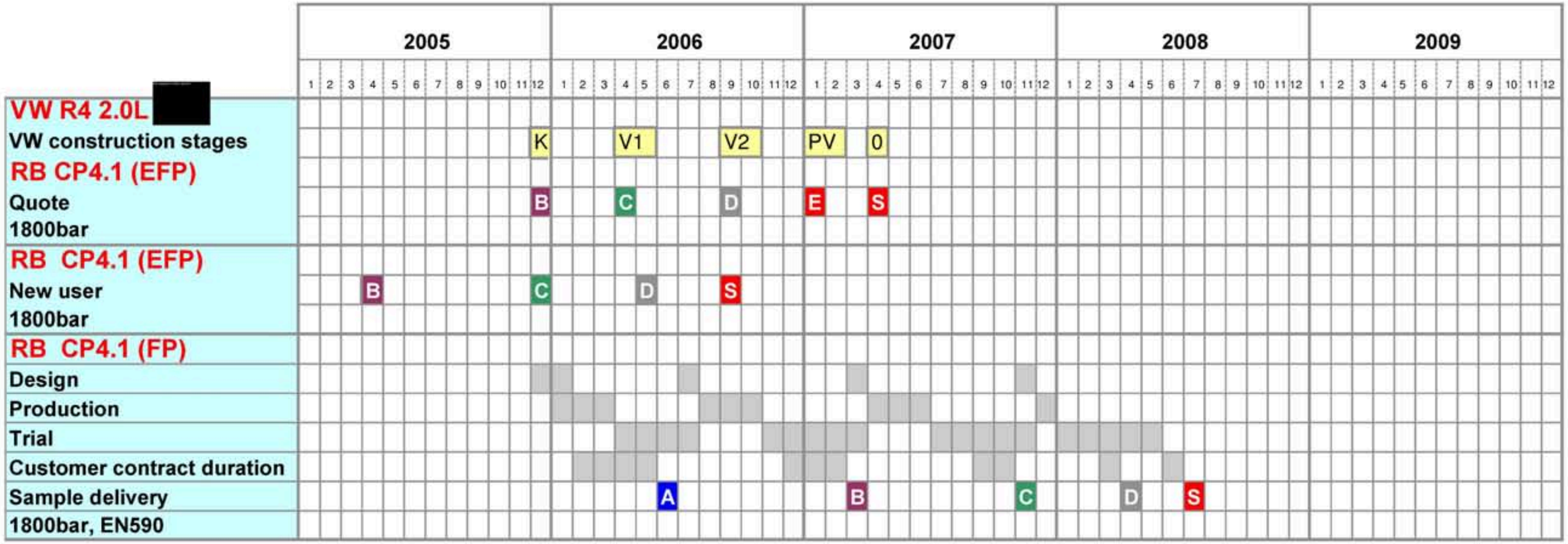
Torque measurements:

- ➔ **Measurements available with 6, 6.75 and 7.5 mm cam stroke**
- ➔ **4.5 and 5.25 mm not yet sampled, will follow later as not critical**

CP4 for VW R4

Annex 1.34

Schedule



VW K Concept V1 BStV100 V2 BStV200 PV Pre-series 0 Pilot series

Bosch A A sample B B sample C C sample D D sample E ISIR S RB-SOP

Remark: Order 5 months before delivery

BOSCH

Assessment of VW-spec. characteristics as at 26/10/

Characteristics (differ from pilot application)	**Implementation** **(K: concept engine WK46/05, M: sample delivery, S: series)**
Height reduction required to protect pedestrians with 2 corresponding dimensions: 1. Reduction of flange material in mounting bore area from r. 12 mm to r. 9.5 mm 2. UM (radial): Height reduction from 118 mm to 112 mm (based on pump center)	→ K: not possible due to delivery deadline → M, S: Feasibility through cast modification or re-working being tested (strength test nec. WK46) → K, M: Reduction to 115 mm is being implemented → S: Feasibility of 115 mm being tested → General: < 115 mm not possible (redesign of housing required) ⇨ Implementing both maximum requirements might not be necessary, being tested by VW

BOSCH

CP4 for VW R4

Annex 1.36

Assessment of VW-spec. characteristics as at 26/10/

3. HP outlet: Orientation VW-specific 30-90° from the transverse axis	→ K, M, S: 90° (to rear) being implemented as agreed	green
4. Shaft: Cone with external thread	→ K, M, S: being implemented	green
5. Housing: Mounting bore with thread instead of through hole	→ K: remains through hole → M, S: being implemented	green
6. Direction of rotation: clockwise	→ K, M, S: being implemented → General: Functional effects are being tested	yellow

→ meeting the space requirement is highly probable, further details to follow (WK46).

→ There are significant differences bet. VW-spec. CP4 and the pilot user.

→ The implementation of characteristic 1 determines the sample lead time in particular; delivery category 3 (90 days) still to be scheduled for reworking or cast modification.

→ Pumps for the concept engine in 12/05 will possess all characteristics listed except points 1 and 5.

CP4 - outlook for 4-cyl. engines

Pump construction for VW 1.6 1/2.0 1 "low"& "high":
HP pumps:

➔ RB proposal (synchronous HP feeding):
1.6 1: CP4.1, ratio i=1, cone drive
2.0 1: CP4.1, ratio i=1, cone drive

LP pumps:

➔ RB proposal:	CP4 in EFP version pot. combined with engine-mounted presupply pump
➔ alternative:	CP4 with integrated mech. gear pump (available from 07/2008)

Note: Pump selection based on estimated delivery rate values and other framework conditions, as no official VW values are available

ENTIRE PAGE CONFIDENTIAL

DS VMU standard lead times 2 Half-year '05

Annex 1.38

	High-pressure pump						Rail		
	1H	N2	3	3NH	4	N5	WFR	LWR2	LWR3/4
Cat.1	**40**	**55**	**40**	**50**	**60**	**70**	**35**	**40**	**50**
Cat.2	**50**	**65**	**50**	**65**	**75**	**80**	**45**	**50**	**60**
Cat.3	**70**	**95**	**70**	**80**	**90**	**90**	**50**	**60**	**75**

	CR injector (car)				CR injector (CV)				DENOX	HCI
	2	3.0 3.1	3.2 3.2	3.3	2	3	4.1	4.2	1, 2, car	
Cat.1	**35**	**45**	**50**	**50**	**45**	**45**	**75**	**70**	**35**	**35**
Cat.2	**45**	**50**	**60**	**60**	**55**	**55**	**80**	**80**	**45**	**45**
Cat.3	**50**	**55**	**70**	**70**	**70**	**75**	**115**	**90**	**65**	**60**

Lead time in working days (80 % - completion)
Capacity-related deviations are possible

Definition of contract categories: see page 2

BOSCH

DS VMU standard lead times 2 Half-year '05

Annex 1.39

Category 1	**Repeat order; check drawings and parts lists no technical changes**
Category 2	**Variant on existing base; blank or cast available as output component**
Category 3	**Redesign; significant deviations from the previous delivery, check installation situation; procurement of new tools and/or output components,**

BOSCH

Cure status AWP (Anti Wear Package), standardization CP4.1

Overview of AWP (Anti Wear Package) sample features (B1)

High-pressure piston:	Lateral surface: C coating
	Piston base: reduced roughness, C coating
Roller support:	Area of contact of the piston base support surface increased and roughness reduced
Roller:	DMO5, finer granularity
	Tip: Area of contact increased and roughness reduced
Camshaft:	Tolerance restriction of roughness and area of contact of the cam track
Spring plate:	Anti-friction paint coating
Housing - tappet hole:	Increased strength through heat treatment

Standardization CP4.1

Bosch scenario:	=>	EU5 first start-up with basic pump
	=>	US07 first start-up with AWP pump
	=>	Unit pump from 09.01 (depending on the decision Non-responsive content removed
VW objective:	**=>**	**Unit pump CP4.1 at first start-up US07 from 08.01**

Author: [redacted]
Date: 04.10.2006
File name: AWP (Anti Wear Package) status, Standardized CP4.1
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About AWP B1-pattern characteristics

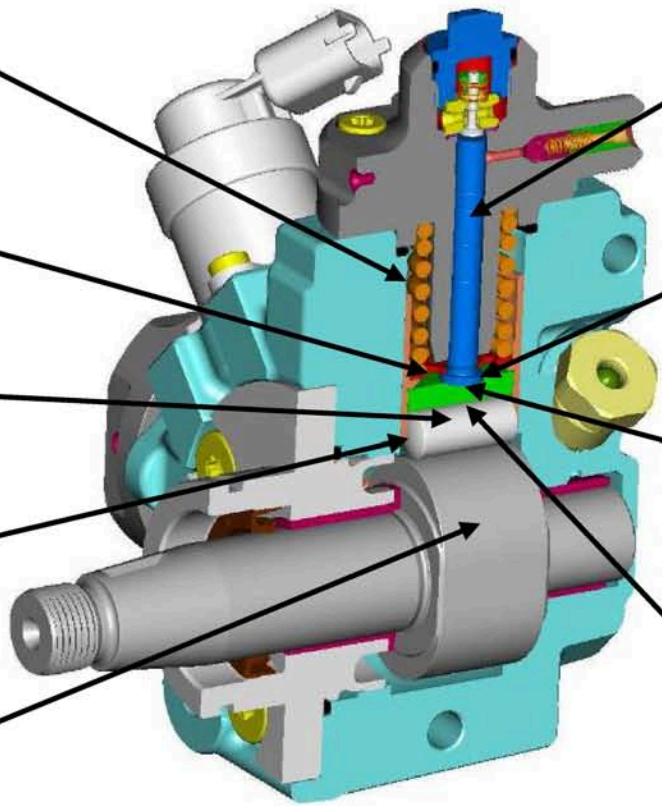
Tappet hole housing
Increased strength through heat treatment

Spring plate
Anti-friction coating

Roller
DMO5, finer granularity

Roller tip
Area of contact of the surface increased and roughness reduced

Camshaft
Tolerance restriction of roughness and area of contact of the cam track



High-pressure piston
C-coating lateral surface

High-pressure piston
Roughness of piston base reduced and C-coating

Roller support
Area of contact of the surface (piston base support) increased and roughness reduced

Roller support
Roughness reduced

CP4 for VW

Robustness Packages (RPx)

RP0

Task: - Reduce wear and tear (especially avoidance of piston seizure)

Content:
- red. C coating on the pump piston
- One-piece carbide coupling (pump with mechanical gear wheel feed pump)

RP1

Task:
- Increasing the load capacity of hydrodynamic lubricating film between the roller / roller support at a lower viscosity and poorer lubricity
- Reserve robustness for temporary overshooting of specification

Content:
- Reduction in the roughness of roller supports, opt. Surface
- Safe prevention of metal chips (process C2)
- Reduction of the roller clearance to the roller support

RP1+

Task: like RP1, additional reduction of wear and cavitation in the tappet hole in conjunction with poorly lubricating and low-boiling fuels, improved load distribution in the roller support

Content:
-like RP1, but C3.1 coating
-Reduction in the radial clearance of tappet body to housing
-Reduction in the axial clearance of piston base to roller support
-Reduced form tolerance of the roller hole in the roller support in conjunction with a radius of 70,000

RP2 task:
- CP4.2: Optimized temperature balance (only for CP4.2 rotating clockwise with EFP)

Content:
- change in position of the inlet hole in the powertrain compartment
- robust flange (enlarged overflow cross-section)

EA11003EN-01859[0]

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Drivetrain Damage Diesel High-Pressure Fuel Pump CP4.2

EA11003EN-01859[1]

Drivetrain Damage Diesel High-Pressure Fuel Pump CP4.2

Summary of activities:

- Current cases of damage 799 bills worldwide, of which 428 in [redacted] – see Appendix (drivetrain damage in approx. 90% of cases)
- Information from [redacted] Task Force:
  - Striking features of fuel (FAME acidity) due to increase from approx. 3% to 7% biodiesel in [redacted] in 2009
  - Damage in [redacted] different from Non-responsive content removed (cam path smoothed, shaft seal worn, etc.)
  - Individual C coating batches feature high failure rates
- Failure hypotheses from Bosch for [redacted] market:
  - Tribochemical wear: Oxidation of camshaft → Oxide adhesion from cam roller → Smoothing of camshaft → Reduction in frictional coefficient (counter to aim of higher frictional coefficient for cam roller / cams)
  - Deposits from biodiesel: Deposits→ Increased frictional coefficient cam roller/roller shoe → cam roller sluggish in roller shoe → slippage between cam roller / cam → Wear + material abrasion
  - Microorganisms in fuel: e.g. algae → Acidity due to metabolic products → Corrosion of am roller + cam shaft → Increased frictional coefficient + Surface damage → Wear + Material fatigue
- Other steps:
  - Continuation of detailed fuel and damaged pump analysis
  - Evaluation of all failure hypotheses / Ishikawa diagram
  - Attempt to reproduce damage mechanism on test bench
  - Comparison of production parameters CP4.2 (Q recordings) without indication of deviations favoring damage → further analyses for previously unspecified parameters (particularly C coating: component geometries)
  - Current status regarding introduction of robustness package (planned SOP July 2010):
    Production + measurement of individual pump parts First test bench results with critical fuel end January 2010

Task Force – Anti Wear Packages @ CP4

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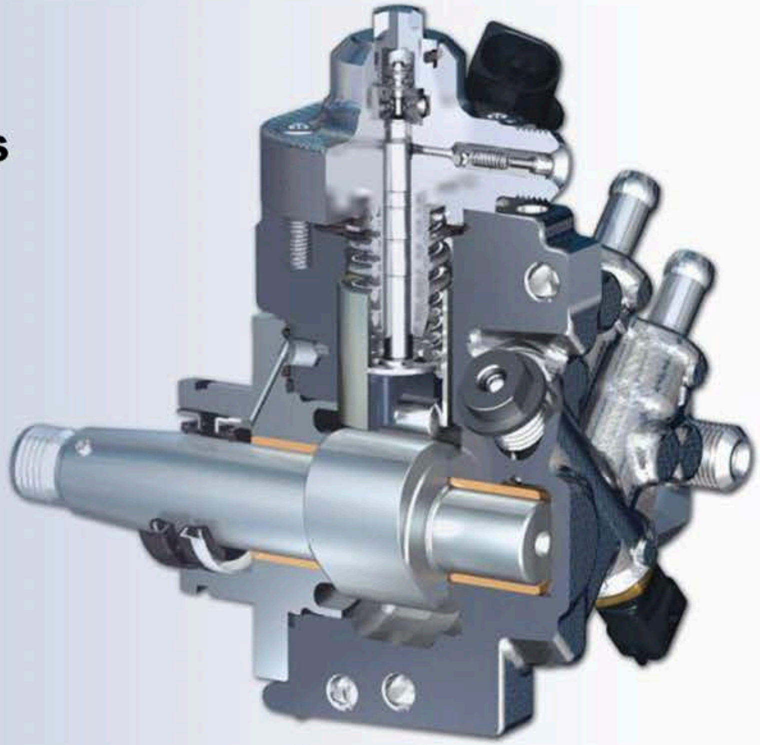
1) **Field situation**
2) **Comparison of injection systems**
3) **(Anti wear package 1 (RP1))**
4) **Anti wear package 2 (RP2)**
5) Non-responsive content removed **pump**
6) **road test pump with RP2**



EA11003EN-01863[1]

1) Field situation

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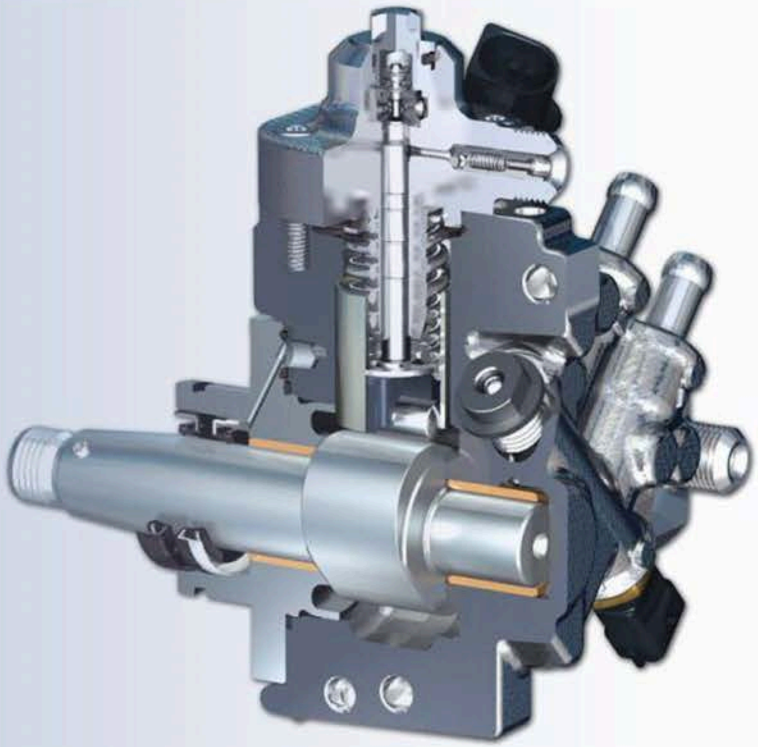
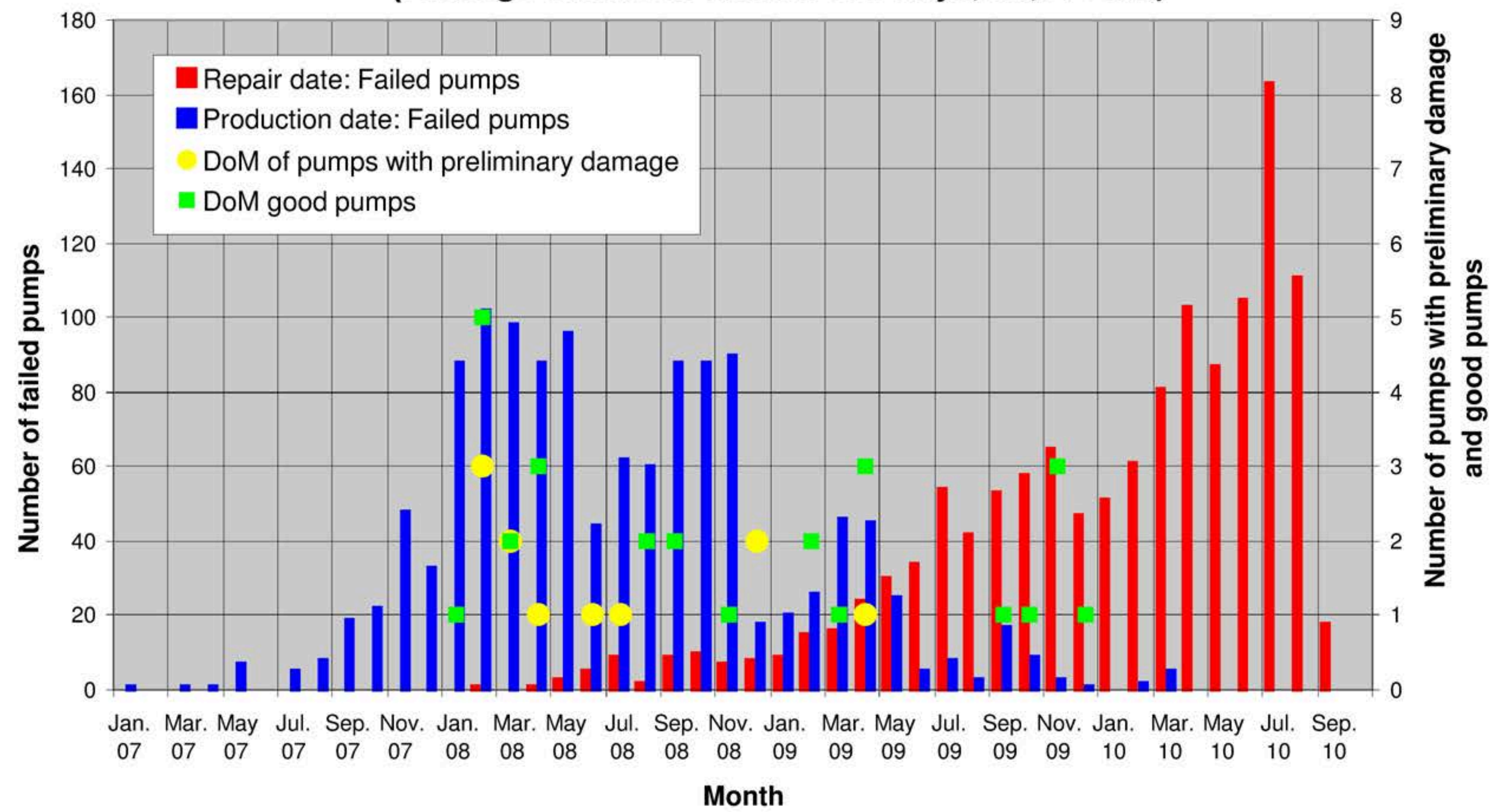


EA11003EN-01863[2]

CP4 Task Force Audi, Failures [redacted]

Production and failure dates of 1282 [redacted] pumps (DoM 07-10)
(Average values to failure: 600 days, 55,818 km)



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Task Force - CP4

Italy:

- Pumps from 2008/9 suffered preliminary damage in [redacted] in early 2009
- Preliminary damage level 20% from analysis of good pumps

Therefore, fuel-related "on-site actions" will only deliver limited findings for further cause analysis, if at all.

Questions:

Why don't the competition have any problems in [redacted]

Why is VW CP4.1 lower than Audi CP4.1 ?

Measures:

- Back measuring: 25 new presupply pumps

  25 low-pressure systems [redacted]

- Check distribution impact and possible aging statistically for the LP system
- Targeted tests with aged biofuel

Task Force – Anti Wear Packages @ CP4

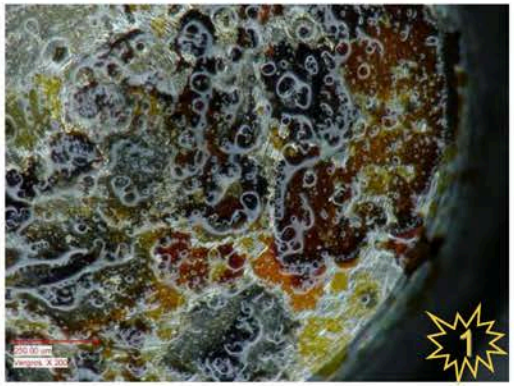
Examples of **aged fuel** on the intake valve (CP4.1[redacted])

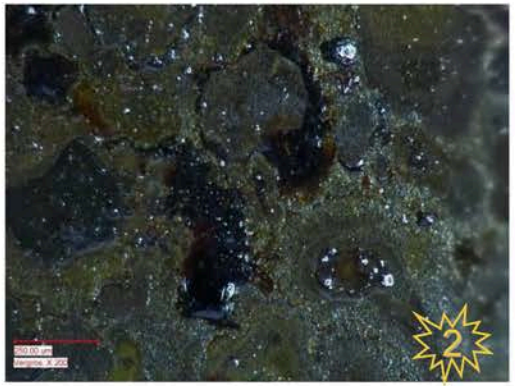
4VW372 DoM Mar 08 35,010 km

No drivetrain damage

4VW4VW354 DoM Sep 09 5,358 km

With drivetrain damage





Diesel systems

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Task Force - CP4

Non-responsive content removed

1. Continued high failure rates, even with 2010 production date
2. High rates of repeated failures in certain areas of Non-responsive content removed

Questions:

Why do pumps with RP1 measures handle our Q and

why do pumps fail so quickly in Non-responsive content removed (300 km)

Why don't any other customers in Non-responsive content removed have problems

Measures:

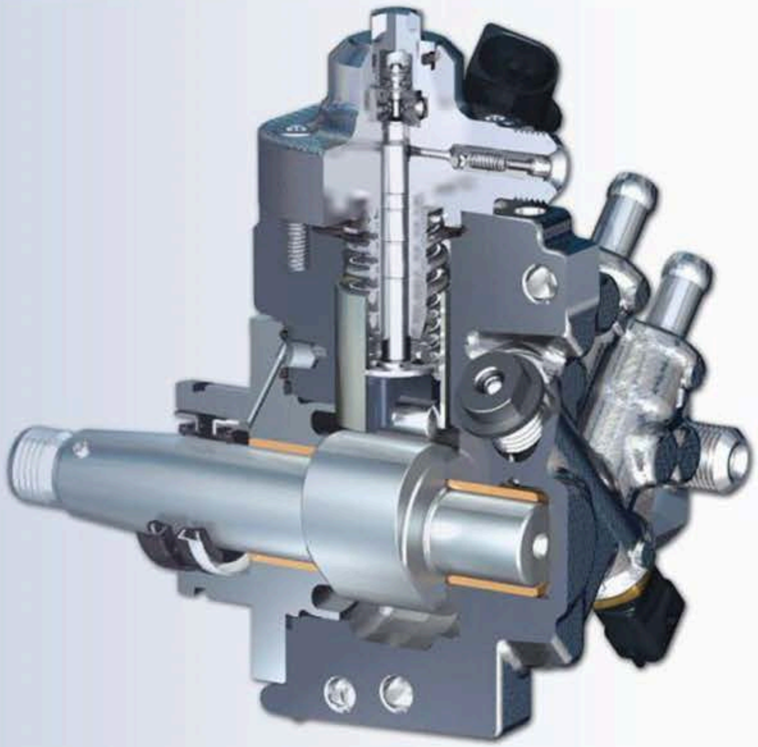
On-site action needed to understand problem.

Quickly bring RP2 pumps to Non-responsive content removed in repeat case

EA11003EN-01863[6]

1) Comparison of injection systems

[redacted]



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EA11003EN-01863[7]

Comparison CP4.2 - FIE

	W19 EU5 (1800 bar)		W36 (1800 bar)		Competition (1800 bar)		Impact on drivetrain damage W19 / competition
Rotation direction	RL		RL		LL		LL temperature advantage
Piston diameter [mm]	6.5		6.5		6.5		No influence in the context of exactness of temperature measurement
Cam stroke [mm]	4.85		5.625		5.25		
Tip circle [mm]	47		47		47		
HP delivery rate [l/h]	81		80		78		No impact
Drive torque [Nm]	min.	max.	min.	max.	min.	max.	Check impact on torque and bending force on W19 temperature compared to competition W36
-Engine	-7	30	-25	57	-13	40	
-PB (@ 4500 rpm, 1800 bar)	-8	29	-10	35	-9	33	
Transverse force on camshaft [kN]	0.4	2.4	~0	2.5	1	4	
OV	OV identical in all CP4 EFP types						No impact
MU	MT 2.0 120 l/h		MT4.2 220 l/h		MT 4.2 220 l/h		No impact, all engines max. 120 l/h at WB

Diesel Systems

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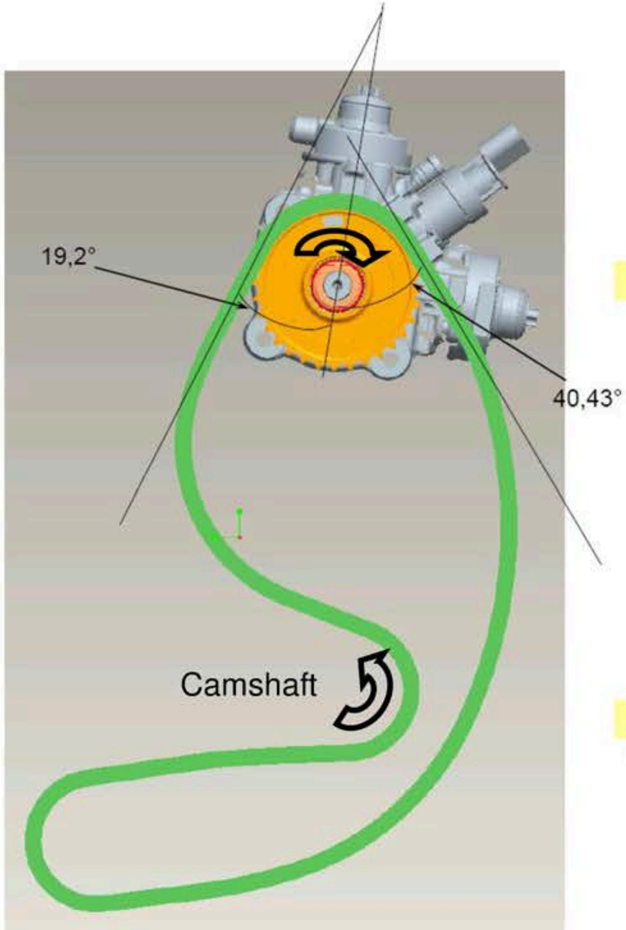
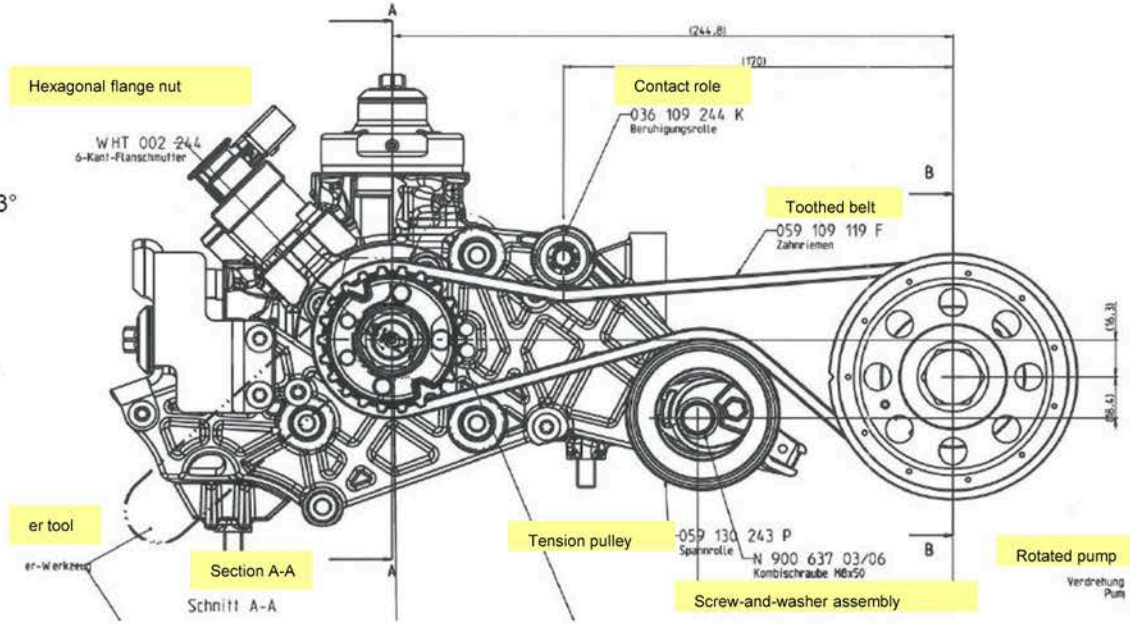
CP 4.2 Portrayal of cam profiles and torque/forces on the pump

Portrayal chain drive W36/W37



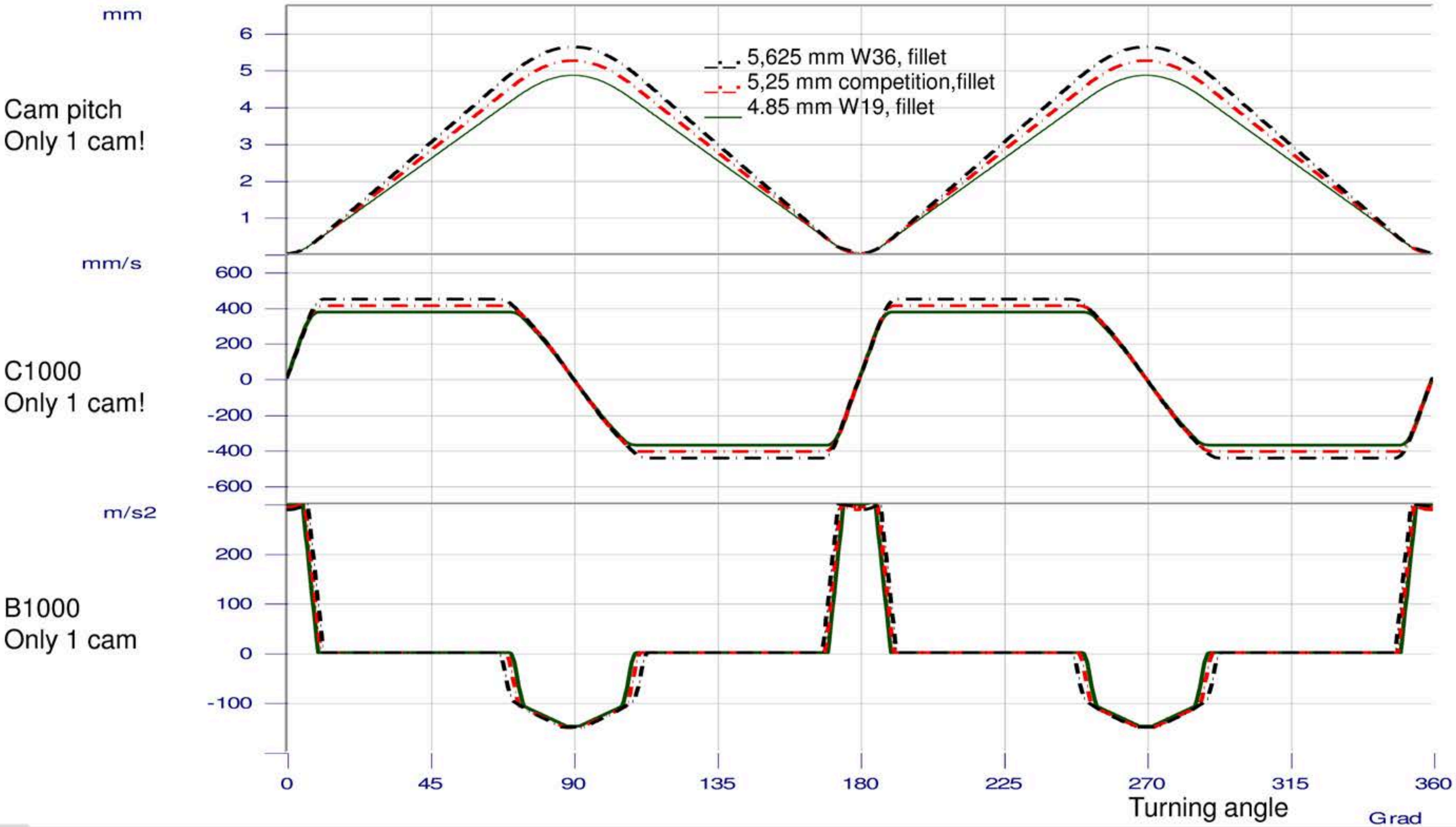
Pump drive W19



EA11003EN-01863[9]

CP 4.2 Portrayal of cam profiles and torque/forces on the pump

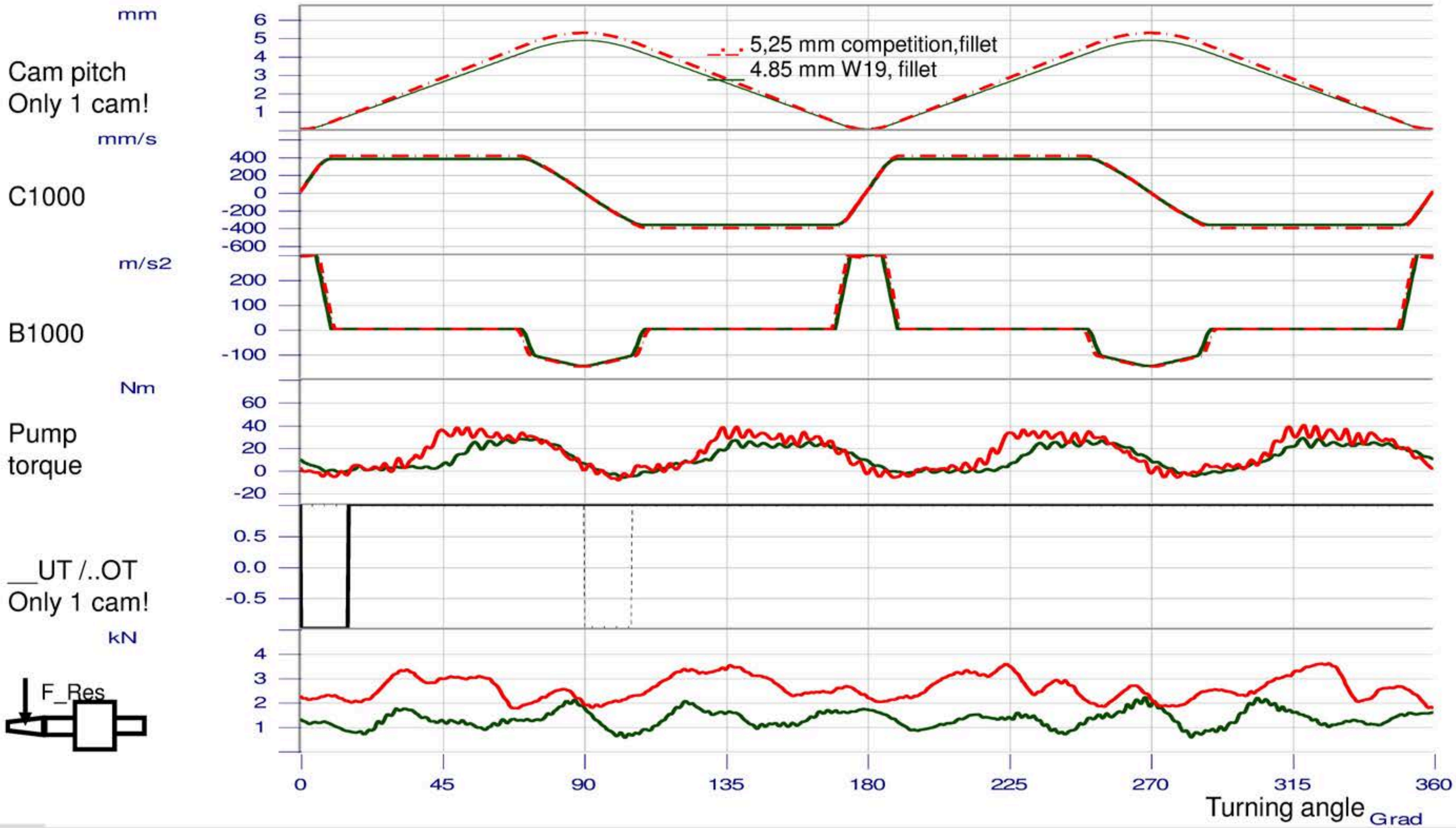
Comparison of cam stroke and cam profiles W19, W39, competition



EA11003EN-01863[10]

CP 4.2 Portrayal of cam profiles and torque/forces on the pump

Measurements W19/W36/competition: Cam profile results: 4500 rpm/s, full load



Diesel Systems

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EA11003EN-01863[11]

CP 4.2 Portrayal of cam profiles and torque/forces on the pump

Measurements W19/W36/competition: Cam profile results: 4500 rpm/s, full load

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EA11003EN-01863[12]

4) Anti wear package 2 (RP2)

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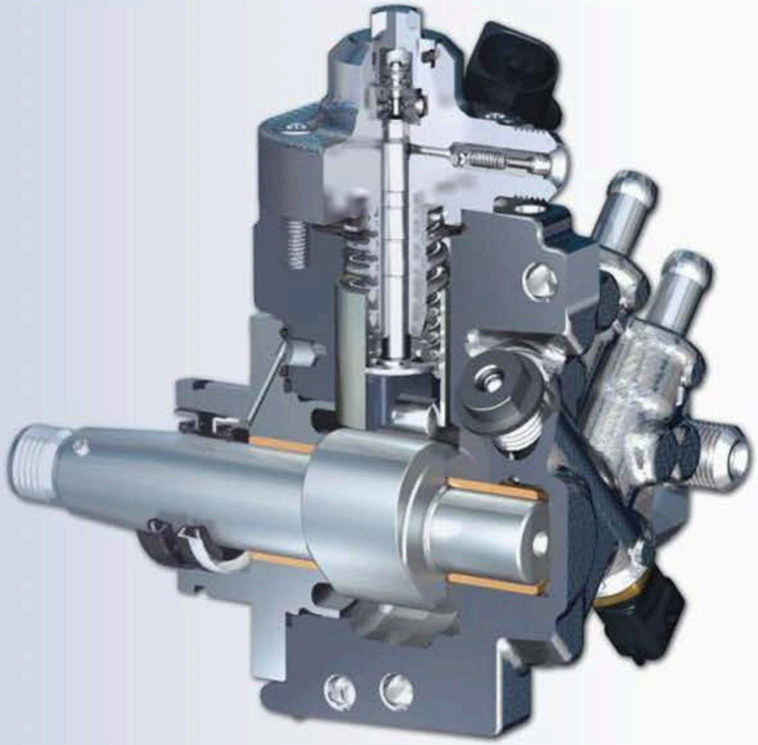

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Task Force – Anti Wear Packages @ CP4

Anti wear package 2

Task

Reduce local temperature in right roller support to level of CP4.1 and CP4.2 CCW

Measures

- Opt. arrangement of inlet & return position (exchange inlet/return connections)
- Introduce robust flange (increase overflow profiles)

Result

Reduction of temperature in lubrication gap by 24°C (from 136°C to 111°C @ 80l/h @ 70°C inlet) in Qold

This is the same level as CP4.1

Test of Qold2 endurance runs at R.B. passed

Pumps delivered to Audi for trial

Serial start planned from week 45

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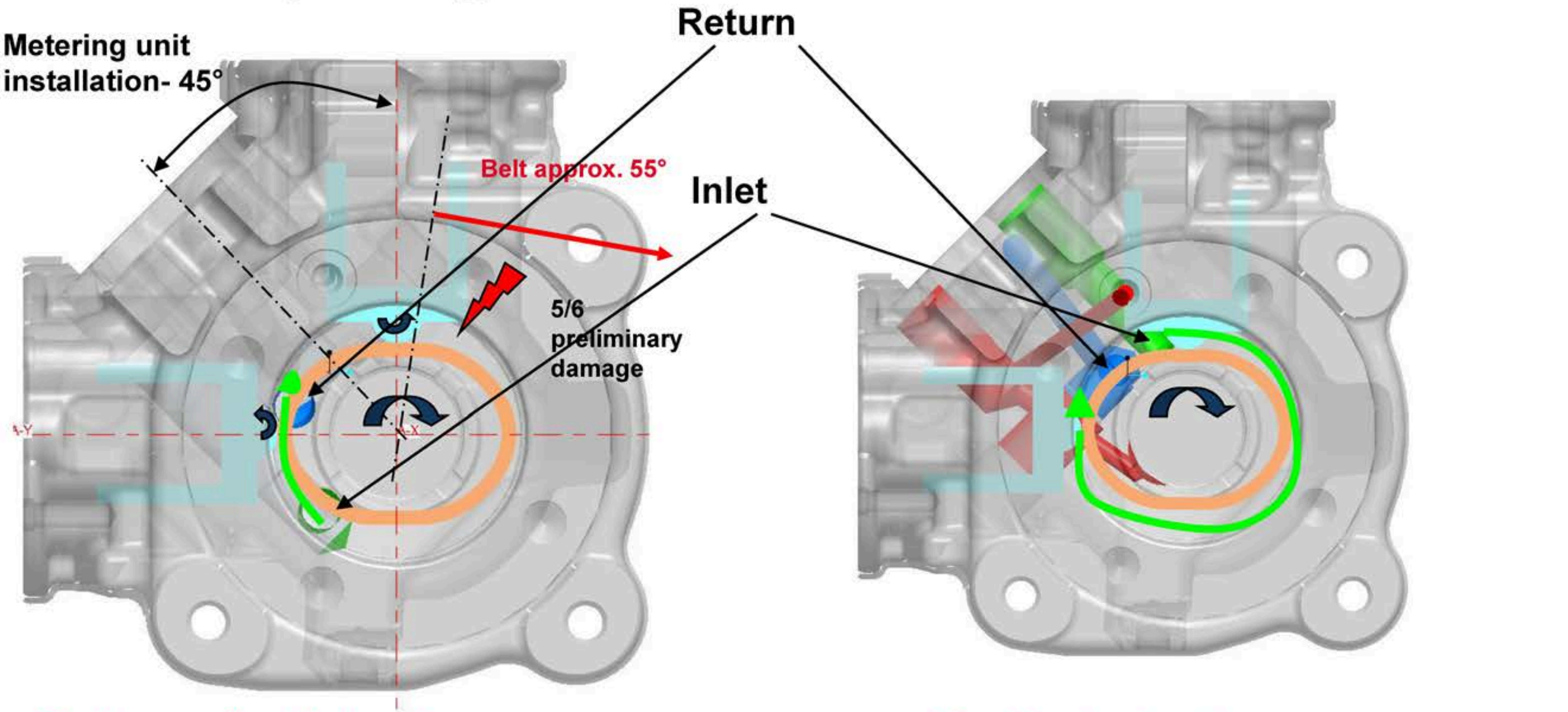
Task Force – Anti Wear Packages @ CP4

Anti wear package 2



Fuel goes directly to return

CP4.2 EFP cw Audi W19

Fuel is circulated once

CP4.2-EKP cw **RP2** for Audi W19

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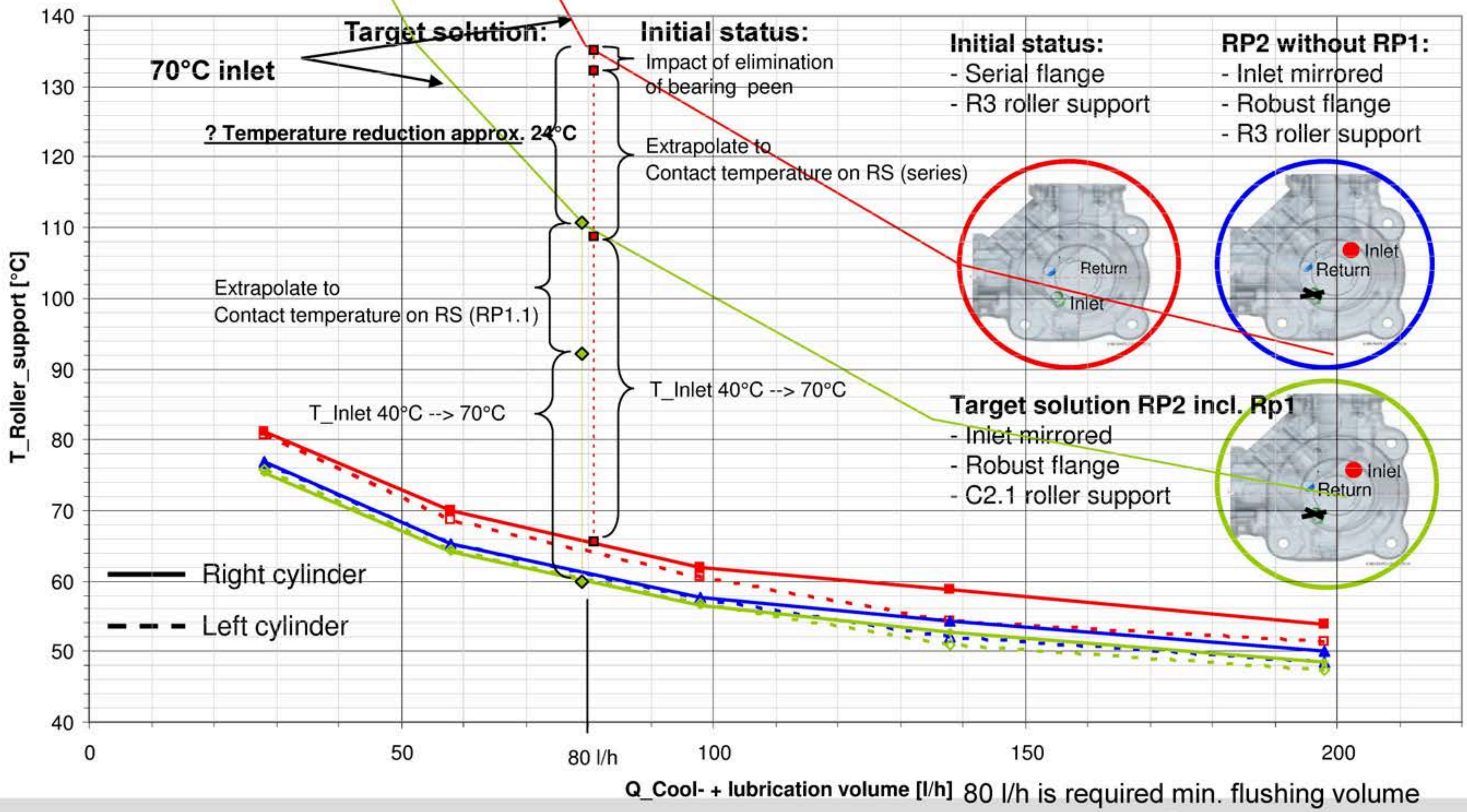
Task Force – Anti Wear Packages @ CP4

CP4.2 Audi W19: Roller support temperature as f(coolant/lubricant volume)

Robust flange; n=1000 rpm; p_Rail= 2300 bar; T_All=40°C



80 l/h is required min. flushing volume

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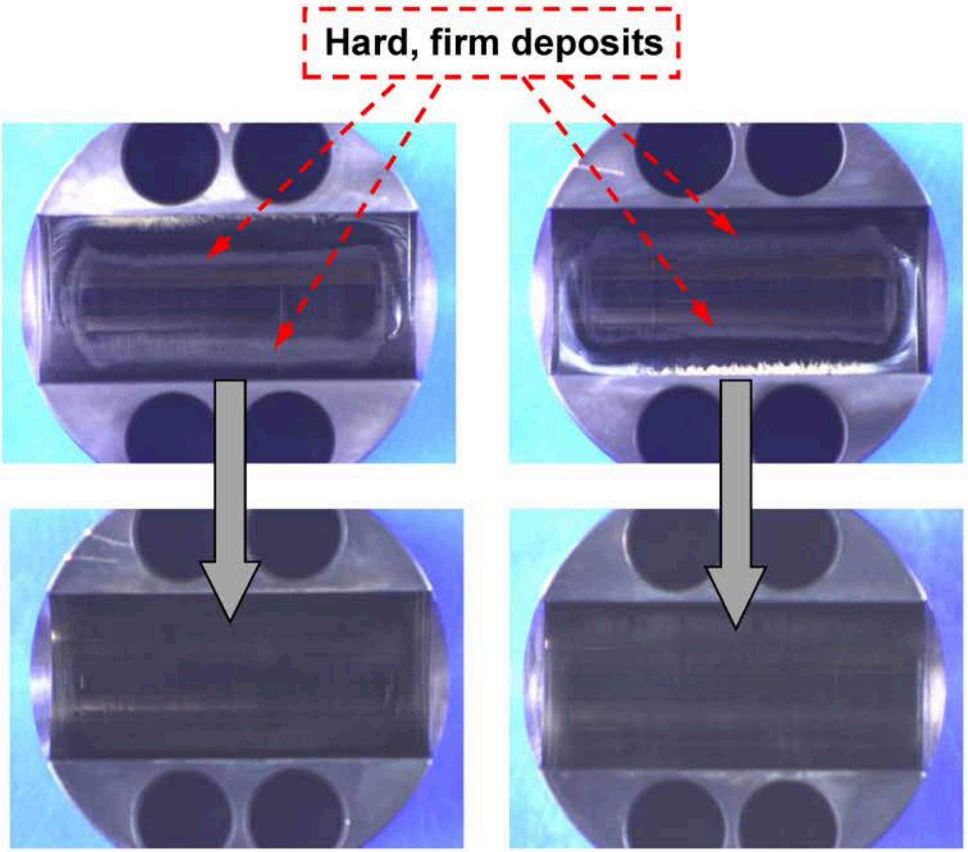
Anti wear package RP2

Proof of effectiveness through overload test (150 h with low viscosity)

Initial status
Series with C3 layer

Reduction
Deposit formation

RP2



Roller support
from test
2009-CP4_0728
uncleaned

Roller support
from test
2010-CP4_304/305
uncleaned

Task Force - CP4

RP2 impact:

Reduction of temperature on right roller support has 2 effects:

- With lower temperature, lubrication gap has higher reduction
- of deposit formation, up to full prevention
  - Better inflow in lubrication gap
  - Tilting movement of roller in start case enables establishment of hydrodynamics

If flushing quantity is reduced greatly, positive impact of RP2 is overcompensated

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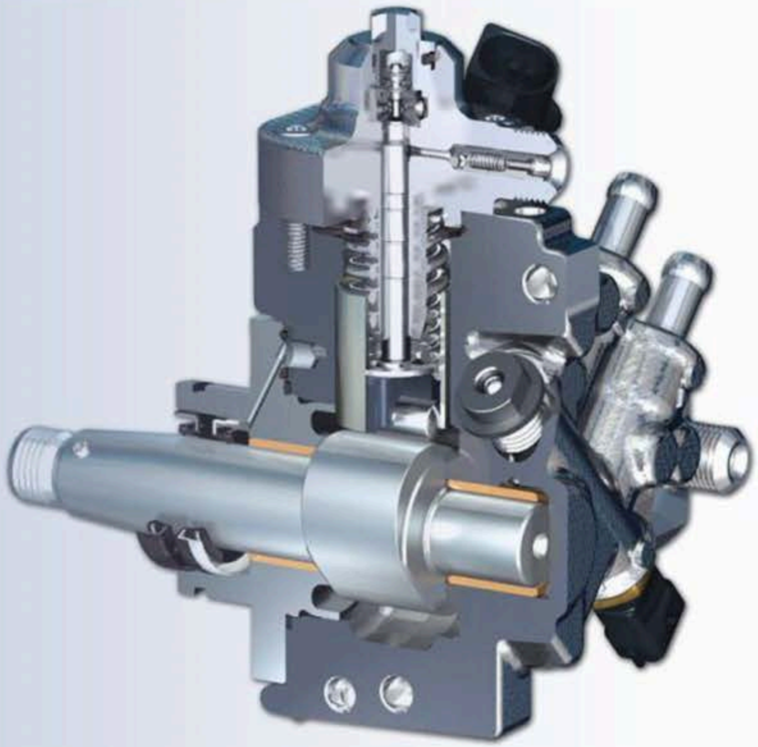
EA11003EN-01863[18]

4) Diagnosis of [redacted] pump [redacted]

[redacted]



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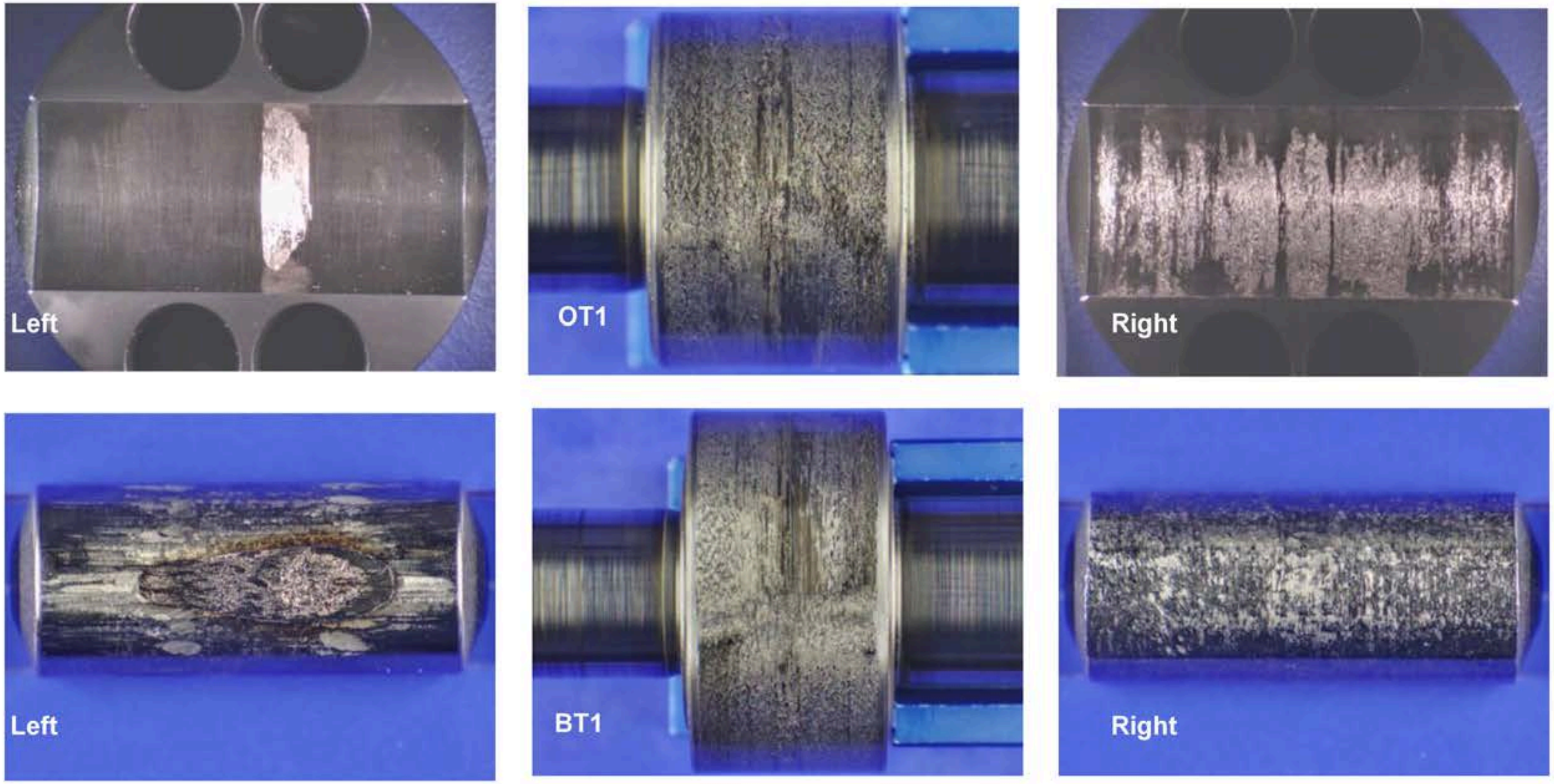
CP4.2 Audi [redacted]

2010-CP4_0644

Failed pump field [redacted] delivery date unknown

0 445 010 611; DoM: 100121 BPT 1190; Chg-Index 05; 059 130 755 AH



Task Force - CP4

Pump shows typical drivetrain damage

Right roller support destroyed first by abrasive wear

Left roller support killed later (turned tappet)

Abrasive wear matches low viscosity in [redacted]

Right roller support: first deal with roller support temperature

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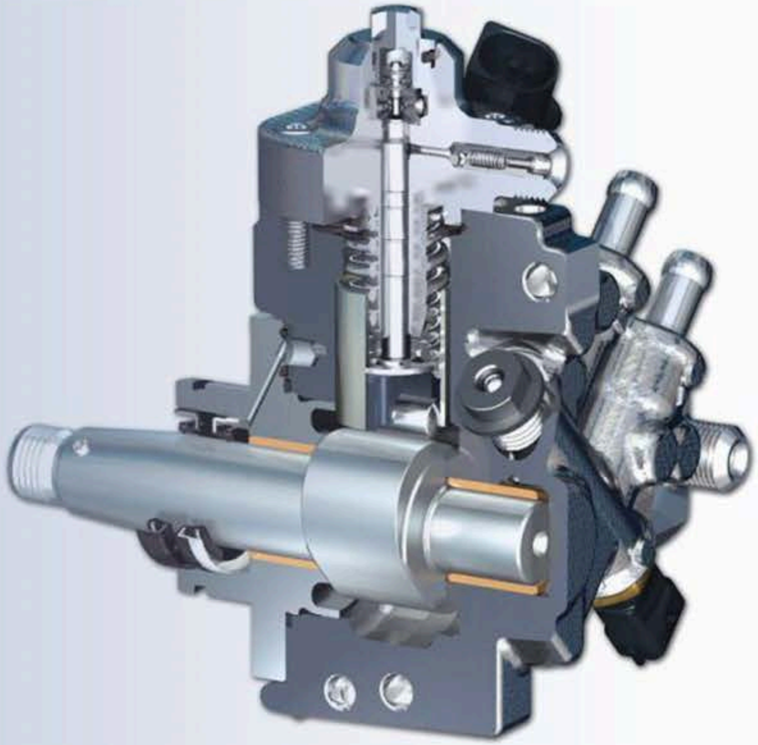
4) Diagnosis [redacted] pump road test with RP2

[redacted]



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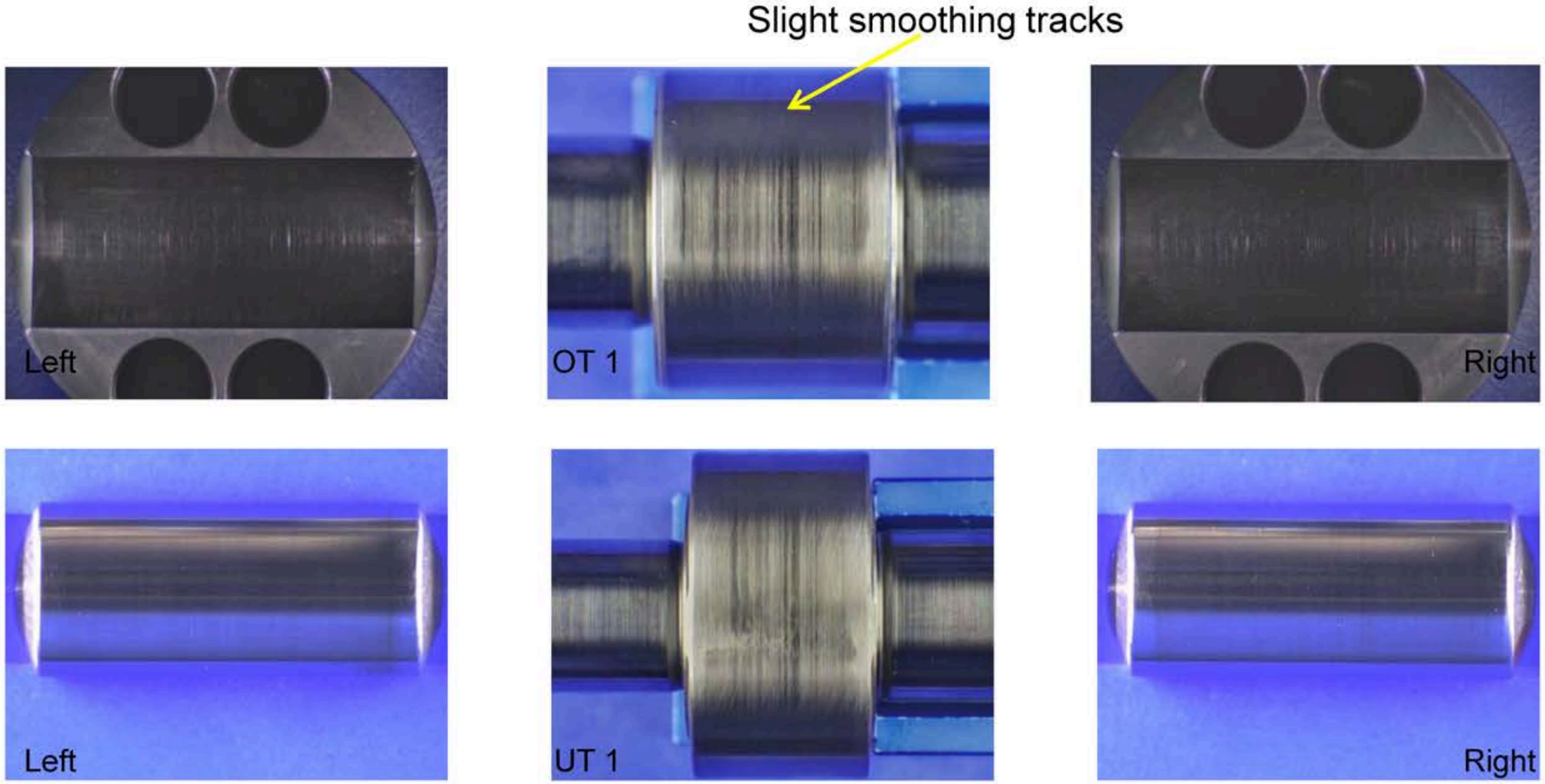
EA10003PN-01863[22]

CP4.2 Audi

2010-CP4_0643 Non-responsive content removed **Test RP2** with 43,189km

W36 0445 B20 321_01; 000005 BPT 4000; ENT 301 181 KL



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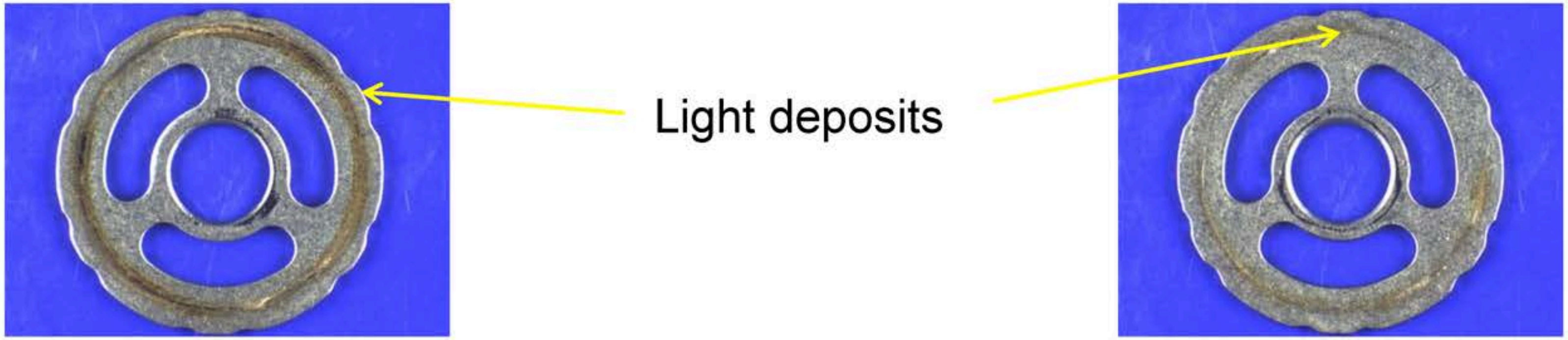
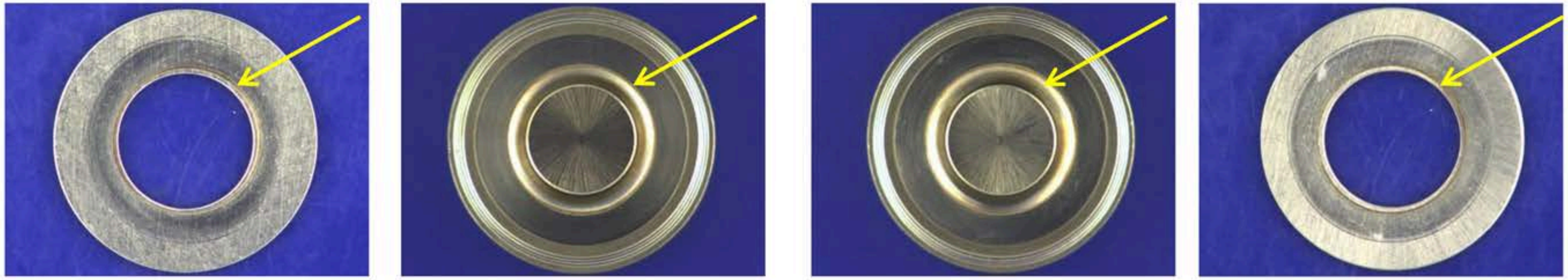
CP4.2 Audi

2010-CP4_0643 Non-responsive content removed **Test RP2** with 43,189km
W36 0445 B20 321_01; 000005 BPT 4000; ENT 301 181 KL



Left

Right



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Task Force - CP4

Pump with RP2 in very good condition after Non-responsive content removed road test

1. Minimal deposits visible in roller support
2. Rollers like new
3. Slight deposits on spring plate

Summary:

Best result of all Non-responsive content removed road tests with 6 cyl.   (6 CRs evaluated)

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EA11003EN-02083[0]

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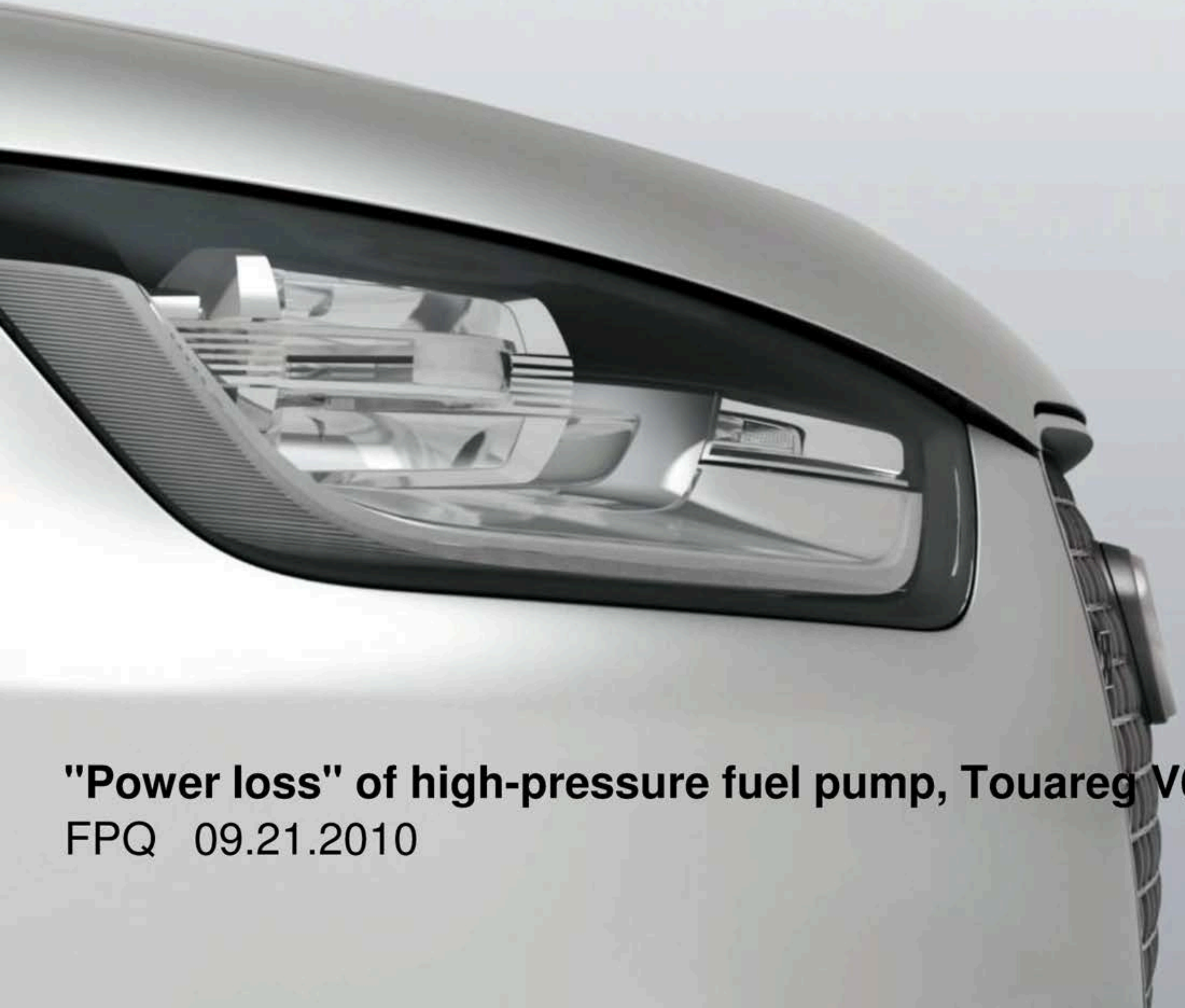


"Power loss" of high-pressure fuel pump, Touareg V6 TDI

FPQ 09.21.2010

Product Quality Forum
- "power loss" of high-pressure fuel pump, Touareg V6 TDI

Problem: Powertrain damage to Bosch high-pressure fuel pumps CP4.2
2135 cases of damage worldwide in low-quality fuel regions (1,150 in [redacted], 284 in [redacted])

Cause: Non-responsive content removed
- aged biofuel in conjunction with high proportion of fuel additives
- low fuel viscosity and poor lubricity

Analysis: [redacted]
- High temp on the right roller support leads to deposits formed from decomposition of the additives
- Deposits impede formation of the lubricant film between roller and roller support
- "Flat spots" cause powertrain damage due to stationary roller of the pump
- Reduction in the frequency of damage by 80% from MY08 to MY10 through measures packages

[redacted]
- Aforementioned fuel properties lead to accelerated component wear
- High temperature on the right roller support leads to further reduction of fuel viscosity
- Abrasive wear due to thin lubricant film between roller and roller supports

Measures:

Robustness package 1 (RP1) Since CW 15/2010

- including C2 instead of C3 coating on roller support; narrowing roller clearance in series for roller support; roller shape optimization
- Increasing lubricant film thickness between roller and roller
- support 8 failures in Non-responsive content removed to date

Robustness package 2 (RP2)

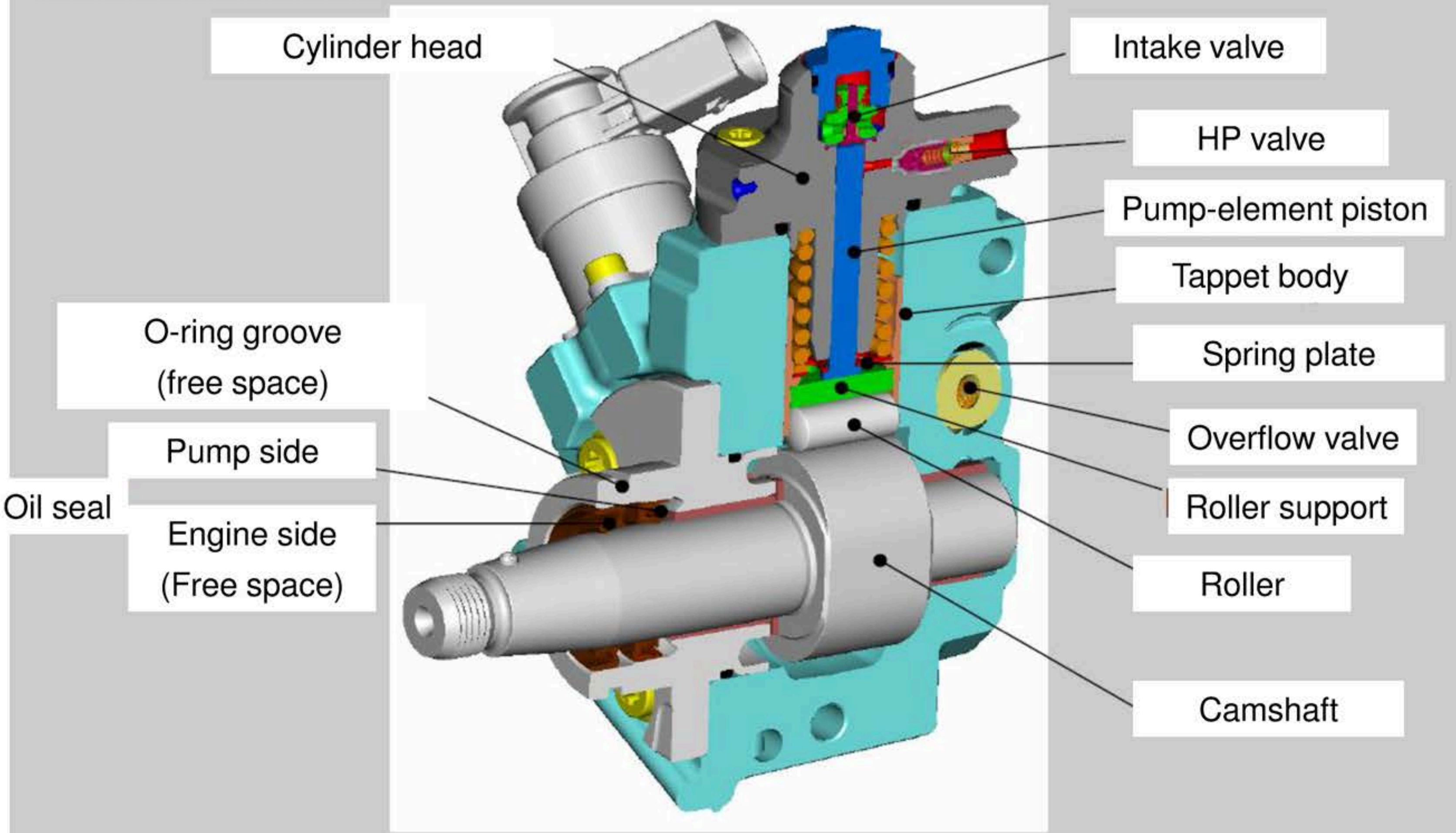
- Reduction in temperature at the right roller support by Opt. Inflow and return lines of the high-pressure fuel pump
- No deposit formation and further lubricant film thickness
- Effectiveness proven in Raff test

Dates: Series RP 2 starting from CW 45/2010 for all V6 TDI

Product Quality Forum

- "power loss" of high-pressure fuel pump, Touareg V6 TDI

Technical information CP4.1



EA11003EN-02085[0]

Audi
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Status of Bosch CP4.2 High-Pressure Fuel Pump in V6TDI Wk38/2011

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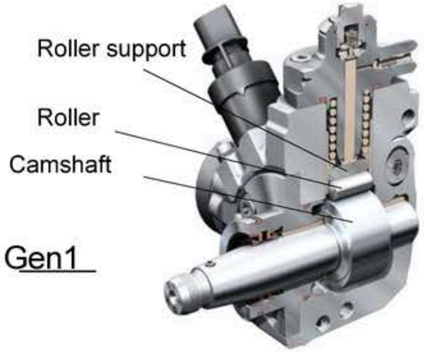
EA11003EN-02085[1]

Status of Bosch CP4.2 high-pressure fuel pump V6TDI Gen1



- **Complaint:** Drivetrain damage to Bosch CP4.2 high-pressure fuel pump in V6TDI Gen1
- **Affected models:** B8, C6, Q5, Q7,Touareg, Touareg NF, Cayenne E1
- **Initial situation/Late 2007: Affected period:** Transition from Bosch CP1h high-pressure fuel pump to CP4.2 for V6TDI Gen1
  Pressure increase from 1600bar to 1800/2000bar - Audi pilot customer for CP4.2
  Note: CP1h in V6TDI Gen1 also OK in countries with poor fuel quality
- **Affected markets:** Countries with poor fuel quality especially [redacted]
  Info: U.S. higher failure rate than [redacted]
- **Known cases of damage:** 3800 Audi and 2300 VW
- **Number of units in field:** 320,000 Audi and 80,000 VW (esp. Touareg, 10% of which in [redacted])
- **Analysis/cause:** Wear due to insufficient lubricating film thickness between roller and roller support

1.) Poor production quality at Bosch in MY 2008 and 2009 80% of all cases of damage involve MY 2008 and 2009
2.) Lack of robustness of CP4.2 for low-viscosity fuels
3.) Coolingof CP4.2dependent on rotational direction/ TCD does not indicate a preferred direction
4.) CP4.2 demonstrates insufficient venting behavior
5.) Sensitivity of CP4.2 to drive influences (torsional vibrations)
No information on drive conditions in the TCD

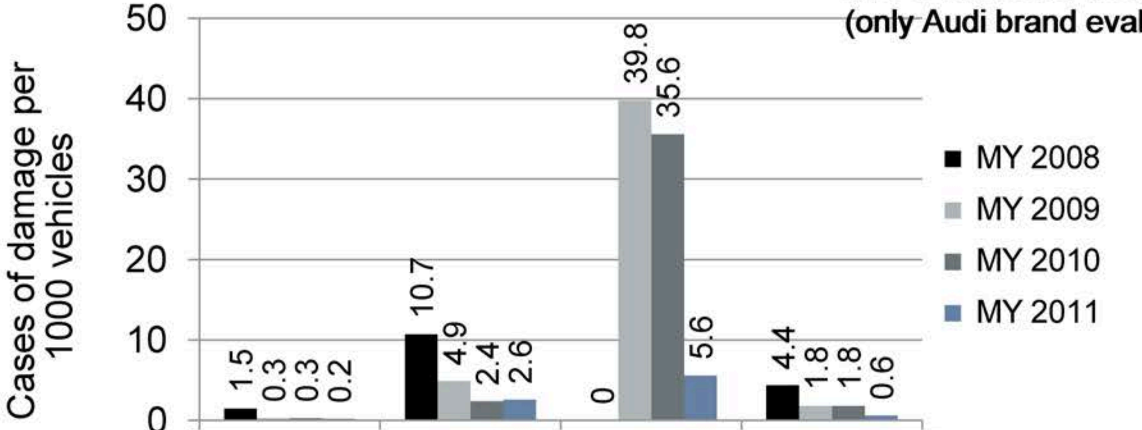
[redacted] Aged biodiesel
Low viscositywith high kerosene and gasoline content

EA11003EN-02085[2]

Status of Bosch CP4.2 high-pressure fuel pump V6TDI Gen1

▶ Actions implemented:	**Measures from package 1&2**	Eliminate quality problems in Bosch productionMP1(Wk30/2008) MP2(Wk30/2009) / After introduction of MP1 and MP2, failure figures in [redacted] OK
	Anti wear package 1 (RP1)	Increase of CP4.2 robustness against low fuel viscosity (Wk15/2010)
	Anti wear package 2 (RP2)	Optimized cooling on right CP4.2 runner (Wk45/2010)
	Optimized EFP activation	Improved CP4.2 cooling during engine start (early 2011)
▶ Planned measures:	**Optimized belt tensioner**	Reduce torsional vibrations on CP4.2 (only for Gen1 Wk45/2011)
	Self-venting CP4.2	Introduction of CP4.2 with optimized venting capability – for V6TDI Gen1 only Cust (possible use from Wk45/2012)
▶ Development in field:	**High effectiveness of measures to date**	

MIS 6 values for V6TDI Gen1 (only Audi brand evaluated)



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